THE TRANSECT METHOD

OF

STREAM HABITAT INVENTORY

GUIDELINES
and
APPLICATIONS

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A technique for sampling general fish habitat characteristics of streams was investigated beginning in 1960 and reported for use in 1967 by the U.S. Forest Service. (Herrington and Dunham). Since 1960, the basic method has been tested and applied to numerous situations including instream flow needs, baseline inventory, project work and land use planning. This paper will document the method and illustrate its application.

The Multiple Use and Sustained Yield Act, Public Law 86-517 (74 Stat.215) states, "That it is the policy of the Congress that the National Forests are established and shall be administered for outdoor recreation, range, timber, watershed, and wildlife and fish purposes." Section 2 of this Act states, "The Secretary of Agriculture is authorized and directed to develop and administer the renewable surface resources of the National Forests for multiple use and sustained yield of the several products and services obtained therefrom." The valuable wildlife and fish habitat provided and the outdoor recreation furnished by the lakes and streams of the National Forests make these among the most valuable areas under Forest Service administration. Because of Congressional direction, the Forest Service considers it is their responsibility to maintain and where possible improve the renewable resources of these high value land and water areas.

The concern for a method to report habitat characteristics is a logical reflection of Forest Service agency responsibility and interest in the fishery resource management program. Since April 17, 1941, when the Chief of the Forest Service, jointly with officials of the International

Association of State Fish and Game Commissioners, defined a partnership role with the several states to conduct wildlife management within and on the National Forests, the desire for more definitive habitat programs has been clearly recognized within the Forest Service (36 CFR 241.2). The Forest Service characterizes wildlife and fish purposes through cooperative agreements with the several States and through management policy and professional staffing.

HABITAT

The term habitat has more connotation than distinction in definition and usage. Davis, 1961, reviewed current literature on the subject of habitat and its concept and concluded, when employed as a discrete term in many of the biological sciences it has become both vague and restricted. He concluded, additionally, it has been confused with environment and biotic communities and other expressions that designate the conditions of the surroundings of particular organisms or group of organisms; but habitat is to be considered distinct from these because it implies more than they signify. Davis proposed a definition of habitat as:

> Habitats are relatively well delimited places or spaces that have sufficient resources of energy and matter to provide the necessary minimum requirements for life. They may be occupied by life, or unoccupied but suitable for occupancy by life. They are abiotic,

> or they are biotic communities and populations of organisms, or a single organism. The life present or capable of being present in them must be sufficiently active to obtain from the habitat some of the resources for its essential functions, if such life is to be referred to that particular habitat. The minimum requirements of life needed by the particular organism are usually made available to it through the agency of the operational environment. This environment is only a part of the habitat.

Haugen reviewed literature on habitat and concluded that the importance of physical habitat as a basis of trout habitat selection cannot be over emphasized, as it not only regulates population density but could well dictate the presence or absence of a trout population.

Platts reviewed literature on all aspects of salmonid production and noted benefits from habitat improvement and deleterious human alterations of trout habitat among the many relationships investigated in the literature review. His study confirms that streams have characteristic distinguishing features which are influenced and controlled by geomorphic processes. The study further documents that the status of fluvial trout populations is determined mainly by the quality of the aquatic environment. Physical characteristics such as mean depth, width, elevation, quality of pool, percent of pool, streambottom materials, and channel elevation had direct effects on determining the quantity and quality of fish numbers and species. Mean stream depth, stream width, and channel

elevation were the most important variables affecting density of fish populations, fish distribution, and fish species composition. To evaluate an aquatic variable by itself could be misleading because it is almost always influenced by other variables.

Several authors have reported on physical feature variables with correlation to aquatic site production levels, carrying capacities, and presence or absence of an individual specie (Barton, Boussu, Burns, Hale, Hunt, Lewis, Shetter, Saunders, and Wesche). Other studies report specific criteria such as water depths, velocities, cover, and streambottom materials in sites occupied during spawning, rearing, and passage or migration periods (Delisle, Hoopes, Ruggles, and Smith). In describing potential spawning sites, Cope was unable to explain use or nonuse by cutthroat migrating from Yellowstone Lake into streams with what seemed to be ideal spawning territory.

> There seems to be a basis for believing that, in a general way, the physical features of stream environments are relatively more influential in streams than they are in lakes, but great care must be exercised in applying such a conclusion, since under some conditions the chemical features modify the whole composition of a stream or portions of a stream.
>
> --from Welch, "Limnology," 1952

Transect methodology defines habitat by the measured physical feature variables. As applied, the analysis methods are biased to cold water species emphasizing salmonids. Modification of the rating scheme and possibly the inclusion of some additional physical feature variables would make line intercept methods usable in non-cold water species habitats.

The method does not singularly measure biomass and fish production and is designed to quantify general fish habitat characteristics of streams. Reconnaissance surveys may be conducted by single line transect stations or ocular estimates when walking along the stream course. Data is recorded on standard forms but noted as reconnaissance level only.

GOALS - OBJECTIVES - ASSUMPTIONS

Goals and objectives to the use of line intercept transect methodology are:

- Define and describe habitat variables.
- Provide convenient, logical stratifications.
- Provide a means to apply statistical measures of precision and accuracy to results and to describe variation.

- Provide a systematic method to quantify physical feature variables.

- Inventory physical features of streams which characterize niches available for the assemblage of aquatic organisms at all aquatic life history stages.

- Relate physical features to other aquatic and terrestrial biotic and abiotics such as streamflows, geomorphic landtypes, valley bottom habitat types, vegetative classes, soil classes, stream stability classes, stream order and others.

- Provide the resource manager with an evaluation of habitat, its potential and limitations, for use in resource display and the decisionmaking process.

- Provide a means to avoid ocular or eyeball appraisals with inherent investigator bias, with the exception that reconnaissance level surveys may be conducted using transect method with few stations and single line samples.

The basic assumption in applying line intercept habitat inventory is that physical features inventoried, i.e., water, streambottom, and streambanks, contain those key habitat variables related to aquatic organism production. It is clearly recognized that production is strongly influenced by species composition, age class distribution, chemistry and

water temperatures among other things. It is also recognized that variation is a fact of life and that physical features within and between streams will exhibit greater or lesser variation. The transect method can be used to measure this variation.

THE METHOD

GENERAL

The survey is a habitat sampling procedure using cross-channel tape measured lines termed transects to quantify habitat variables. This is done by tightly stretching a tape measure across and above the water surface at right angles to the direction of streamflow. The tape measure forms the line underneath which habitat features of water and streambottom are identified. It is then a matter of quantitatively stating the habitat by entry of lineal measurement figures (i.e., feet of intercept) in appropriate column of the field form. Streambank habitat is measured at the cross-channel line's exact streambank point of live water contact.

Stations should be located along all portions of stream channels to describe fishery-aquatic habitat resources. Beaver ponds along transect lines are noted and properly coded on the station form.

Quality factors do enter into the field inventory. For example: Suppose a fish pool determined to be two feet in width had been intercepted along a transect, the number "2" would be entered into the field form column "Width" under the heading of "Pool," and in addition a quality or rating factor would be determined from an appraisal of the full pool size and cover features. When a divided channel is sampled, each channel is measured and cumulative entries are made as for one transect on the field form.

MATERIALS NEEDED

Accurate map or aerial photos

Tape measure

Abney level or clinometer

Good quality heavy duty yardstick or metric scale stick

*Supply of stakes

*Plastic strip flagging for use as needed

Metal core clothesline with end markers for 50 foot length

Field clothing and waterproof foot gear for wading

Field data sheets

*Stream velocity meter

*Camera (if photographic record is planned)

PREINVENTORY PREPARATION

Prior to entering the field, streams to be inventoried are premapped using aerial photographs and geologic survey maps or other appropriate maps preferably two-inch to one-mile scale. Convenient strata are outlined on these maps or photographs and sample stations are marked on the maps and transect spacings determined. As outlined by Herrington and Dunham, 1967, and Collotzi, 1975, random or gradient stratification of sample stations is used and at the selected intervals of streamcourse,

*Items which are needed only if required through pre-planning.

station locations are pinprecked or otherwise marked on the map. Statistical precision, sample size, and transect spacings are discussed by Herrington and Dunham.

LOCATING SAMPLE POINTS IN THE FIELD

The field crew will locate points on streambanks that coincide approximately with sample stations marked on maps and aerial photos during preinventory. Possible bias on the part of the field crew in locating the sample station is eliminated by having the crews establish transects beginning exactly one hundred feet upstream from the point first identified on the ground.

TRANSECTS

Transects fall at selected intervals of a control base which follows along one streambank along the edge of live water. Succeeding cross-channel lines originate along this control base and the recommendation is for 50-foot interval uniform spacing between transects to complete the sample station. However, at times control base offset is necessitated due to dense and impenetrable growth of streambank vegetation. When offset is needed, control base should be transferred to stream channel center. The transect extends across the stream channel at a 90-degree angle to its centerline and will be extended at divided channels to include all channels, although only water surface measurements are entered in the field form. All transect measurements are recorded to

the nearest foot. Bank measurements are recorded observations taken at exact waters edge points of transect. All measurements are recorded on the Stream Station Form.

CHARACTERISTICS MEASURED

The Stream Station Form has been designed for use in the field and contains entry spaces for all characteristics to be measured. Information on this form occupies spaces which are used in the computer center. By using this form, the investigator will have recorded characteristics information directly transferrable to data processing systems and totals, summaries, and statistical measures can then be machine calculated and a printed record received as requested. Measurements and descriptions recorded only once at the station are included on the field form along with transect habitat data.

Stream Station Entries - Entries at items 1 through 21 are recorded only once for the station. A detailed description of the entry data will be found in the appendix titled Aquatic Habitat Inventory, Computer Storage Program, Guidelines.

Transect Entries - Data will be entered in the table section of the field form under the 3 headings: water surface, streambottom and bank measurement. Transect 1 will be recorded along the line labeled Card Code 3. Likewise, transects 2, 3, 4, and 5 will be recorded along Card Code 4, 5, 6, and 7, respectively.

Water Surface - All width measurements are to the nearest foot interval and the investigator will classify water into pool-like or riffle-like environments for entry into field forms. Protruding rocks, stumps, or logs are to be included in width measurements. Channel width is the width at high water mark or bank full capacity when high water marks are not discernible. Total width is the width of water surface at the time of survey.

Average depth is recorded to the nearest tenth of a foot. Measure depth in inches at intervals one-fourth, one-half, and three-fourths the distance across the channel. The depth readings are averaged by addition and division by 4 which gives weight to zero depths at bank points.

Riffle width is the difference between total width and the sum of all pool widths.

Pools - For each pool, record the width, rating, location, and feature. The form allows for up to 3 pools along any transect. Guidelines and coding are found on the back of the field form. A good fishpool is generally deeper and wider than the average width and depth of the stream. The current within it is appreciably slower than that upstream or downstream from it or hiding places for fish such as overhanging banks and boulders are more extensive than in adjacent parts of the stream. Each pool is rated 1, 2, 3, 4, or 5. The pool is recorded as in contact with right or left bank or as center if not bank associated. Coded entries are described. Significant features of pool cover are

recorded as boulder, overhanging bank, water depth, surface turbulence, and vegetation if tree roots form a major feature of the pool. Coded entries are described and 2 entries for each pool can be recorded.

Record measurements of rooted aquatic vegetation occurring along the transect.

Streambottom - Six types of bottom material are defined as follows:

Boulders (B) - rocks over 12 inches in diameter.

Rubble (R)1/ - rocks 3 inches to 12 inches in diameter.

Gravel (G)2/ - rocks 2.9 inches to 1/8 inch in diameter.

Sand (S) - very fine textured soil, less than 1/8 inch in diameter.

Silt - very fine textured soil, less than 1/8 inch in diameter, less granular than sand.

Other (O) - other conditions not falling into the other four categories: i.e., a sunken log, decaying vegetable matter. Enter type number in column 68 as:

1. Bedrock
2. Sunken log
3. Decaying vegetable matter
4. Other

1/ Coarse rubble - 6-12 inches diameter

Fine rubble - 3-6 inches diameter

2/ Coarse gravel - 1-3 inches diameter

Fine gravel - 1/8-1 inches diameter

Bottom material is not always visible because of suspended silt, shadows, or water depth. Classification in such cases is based largely on the "feel" of the bottom as the fieldman wades along the transect. Therefore it is impractical to detect any bottom type less than 1 foot long. The combined lineal footage of each type of bottom material is measured and recorded to the nearest foot.

Bank Measurement - Right and left banks are identified while facing downstream.

Environment is the class of vegetation precisely at and overhanging the transect points at water's edge. Three types of vegetation are recognized:

Forested - Streambanks bordered by growth of tall trees.

Brush - Streambanks bordered by dense growth of low brush. (Alders, hawthornes, willows, low herbs and grasses.)

Exposed - Streams flowing through pasture and meadow areas, their banks lacking the larger shrubs and trees. Grasses and low herbs are the only vegetation present on the banks.

Environment code will be recorded in column 72 and 74 as:

1. Forested
2. Brush
3. Exposed

Bank stability is rated at each transect total width bank points. An unstable rating is given if there is any evidence of soil sloughing within the past year. On multiple channels, only the 2 outermost banks are rated.

COMMENTS

Include pertinent comments which may give insight into the potential of the stream. Include water stage, fish presence, occurrence of beaver ponds, obstructions or barrier falls, irrigation canals, manmade features, type of access (i.e., improved highway, graded road, Forest Service trail, 1 mile from highway, etc.) suspected pollution including siltation and any other comments you may want to enter. The investigator's observation should include comments on segments of stream not within boundaries of the sample station.

Other information will be recorded as determined during preinventory preparation. Sketches of valley bottom cross section, stream channel profiles, and discharge measurement are among other types of information.

THE COMPUTER PROGRAM

DESCRIPTION

There are two separate forms used for this program - the Stream Identification Form which is filled out in the office and the Stream Station Form to be used for each station on the stream and has been designed for use in the field.

This computer program provides the fishery biologist with the opportunity to store aquatic habitat inventory data and the forms were prepared for use with Control Data Corporation CDC 3200 computer. Once the data has been stored, it can be manipulated using various programs already developed for the computer or it can be recalled as it was placed in the computer for later reference. The value of the output information is directly proportional to the quality of raw data input and the innovative application of results to management situations.

The Appendix contains details of this computer program.

Stream Aquatic Habitat Inventory
(Coded for Computer)

Print or Type

STREAM IDENTIFICATION FORM

Stream _____ Forest _____

Date _____ Investigator _____

1 - Card Code $\frac{1}{1}$ 2 - State $\frac{\quad}{2\ \ 3}$ 3 - Forest $\frac{\quad}{4\ \ 5}$

4 - Catalog No. $\frac{\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad}{6 \qquad\qquad\qquad\qquad\qquad\qquad 19}$

5 - Location:Longitude $\frac{\quad\quad\quad\quad}{20 \qquad 24}$ Latitude $\frac{\quad\quad\quad}{25 \qquad 28}$

6 - Total Length $\frac{\quad\quad\quad}{29 \qquad 32}$ 7 - Stream Order $\frac{\quad}{33\ \ 34}$

8 - Name of Stream $\frac{\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad}{35 \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad 57}$

$\frac{\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad}{58 \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad 80}$

POOL RATING GUIDE

Pool rate	Pool length or width	Pool depth	Pool shelter* (cover)
1	Greater than av. stream width	2' or deeper	Abundant 1/
	Greater than av. stream width	3' or deeper	Exposed 2/
2	Greater than av. stream width	2' or deeper	Exposed
	Greater than av. stream width	-2'	Intermediate 3/
	Greater than av. stream width	-2'	Abundant
3	Equal to average stream width	-2'	Intermediate
	Equal to average stream width	-2'	Abundant
4	Equal to average stream width	Shallow 4/	Exposed
	Less than average stream width	Shallow	Abundant
	Less than average stream width	Shallow	Intermediate
	Less than average stream width	-2'	Intermediate
	Less than average stream width	+2'	Abundant
5	Less than average stream width	Shallow	Exposed

*Shelter = Logs, stumps, boulders in or overhanging pool. Dense beds of aquatic vegetation or overhanging banks.

1/ Abundant = More than 1/2 perimeter of pool has cover.

2/ Exposed = Exposed (little or no shelter or cover) less than 1/4 of pool perimeter has cover.

3/ Intermediate = 1/4 to 1/2 perimeter of pool has cover.

4/ Shallow = Approximately equal to average stream depth.

KEY FOR FILLING OUT FRONT OF FORM

Item 11 - Beaver Influence

1 - Active beaver dams present.
2 - Inactive or old beaver dams present, but in good condition.
3 - Inactive or old beaver dams present, but in poor repair.
4 - No beaver activity present.

Item 17 - Geology Landform

Landform	Valley Bottom Material
1. U-shaped valley	moraine
2. U-shaped valley	alluvium
3. U-shaped valley	bedrock
4. V-shaped valley	moraine
5. V-shaped valley	alluvium
6. V-shaped valley	bedrock
7. planar landform	moraine
8. planar landform	alluvium
9. planar landform	bedrock

Item 18 - Access

1. satisfactory for modern car
2. not too good, but can be reached by car
3. jeep, horseback or foot
4. horseback or foot on trail
5. no trails

Code Cards 3 through 7

Pool Rating:

Pool Location: 1-right bank 2-left bank 3-center if not bank associated

Pool Features: 1-boulder 2-overhanging bank 3-water depth 4-vegetation or tree roots 5-log jam 6-beaver dam 7-rock outcrop 8-surface turbulance and velocity 9-other

Type-space 72: 1-bedrock 2-sunken log 3-decaying vegetable matter 4-other

Environment-space: 1-forested 2-brush 3-exposed

Stability-space: 1-stable 2-unstable

Use this space to sketch cross section of valley bottom.

USDA Forest Service

STREAM AQUATIC HABITAT INVENTORY
(Coded for Computer - Print or Type)
Stream Station Form

Stream _____ Forest _____

Date _____ Investigator _____

Card Code 2/1 Photo No. _____

1 - State (2-3) 2 - Forest (4-5) 3 - Catalog # (6-19) 4 - Date of Sample (20-23) 5 - Station No. (24-26)

6 - Location: Long. (27-31) Lat. (32-35) 7 - Sample No. (36-37) 8 - Gradient (38-39) 9 - Velocity (40-42) 10 - Volume cfs (43-47)

11 - Valley Bottom Width (48-51) 12 - Beaver (52) 13 - State Class (53) 14 - Fishery (54-58) 15 - Endangered-Threatened Species (59-61)

16 - Invert.: gms/meter sq. (62) Div. Index (63) 17 - Geologic Class (64) 18 - Geology (65) 19 - Access (66) 20 - Temp.: Air (67-68) Water (69-70)

21 - Time of Day (71-74) 22 - Elevation (75-79)

19 A

	WATER SURFACE				POOLS											STREAM BOTTOM							BANK MEASUREMENT	
					1				2				3										Left Bank	Right Bank
CODE CARD	Channel Width	Water Width	0.00 Average Width	Riffle Width	Pool Width	Rating	Location	Feature	Pool Width	Rating	Location	Feature	Pool Width	Rating	Location	Feature	Aquatic Plants	12+	6 - 12 3 - 6	1 - 3 1/8 - 1	Sand	Silt	Type	Other	Envir. Stab.	Envir. Stab.
1	20. . .23	24. .26	27. .29	30. .32	33. .35	36	37	38.39	40. .42	43	44	45.46	47. .49	50	51	52.53	54. .56	57. .59	60. .62	63. .65	66. .68	69. .71	72	73. .75	76 77	78 79
3																										
4																										
5																										
6																										
7																										

COMMENTS _____

Sketch cross section of valley bottom on reverse side and show % slopes above valley bottom.

SOME APPLICATIONS

Applications of results have been directed into habitat ratings, base inventory, project evaluation and land use planning. The investigator, during preinventory preparation, must prepare an inventory plan geared to expected needs. The following sections illustrate application to some management situations.

HABITAT RATING

A procedure was developed to determine a habitat percent of optimum value. The concept of a habitat rating is similar in appeal to the stream rankings prepared by many of the States. However, the habitat rating does not consider production levels, access, angling success, and similar factors.

Habitat of each sample is rated in the four categories of pool measure, pool structure, streambottom and stream environment which leads to the final habitat percent of optimum. All ratings use a numerical score system.

Pool Measure - a rating of the total sample width in cover elements of pool and riffle.

- When pool width is 50 percent of total width, rating is 100 percent.

- When pool width, p, is less than 50 percent, solve: 100-[(50-p)x2] = % rating.

- When pool width, p, is greater than 50 percent, solve: 100-[(p-50)x2] = % rating.

Pool Structure - a rating of pool quality.

$$\text{Percent rating of Pool Measure} \times \frac{\text{Total feet of 1, 2, 3 rated pools}}{\text{Total feet in pools}} \times 100 = \text{Percent rating of Pool Structure}$$

Streambottom - percent of total sample width over gravel and rubble bottom.

$$\frac{\text{Feet of gravel + feet of rubble}}{\text{total feet in streambottom sample}} \times 100 = \text{Percent rating of Streambottom}$$

Stream Environment - a rating of streambank vegetative cover in order of tree, brush, grass and exposed.

- Count for each bank point as follows:

Tree = 4 points

Brush = 3 points

Grass and Exposed = 1 point

Add the points for bank environment observations to obtain a total for the sample. Then proceed as follows:

$$-\frac{\text{Total points for observations}}{\text{Maximum possible points if all observations were recorded as tree}} \times 100 = \text{Percent rating of Stream environment}$$

Habitat Percent of Optimum:

$$-\frac{\text{Pool measure + pool structure + stream-bottom + stream environment}}{400} = \text{Habitat percent of optimum}$$

The stream ratings and descriptions for evaluation purposes will be:

Habitat

1. Percent of optimum rating
2. Description and discussion of rating and categories

Other

1. Average depth (inches or feet)
2. Rooted aquatic vegetation (percent of total width of sample)
3. Bank stability (percent of total points)

4. Water velocity (feet-per-second)
5. Access type

Write up report

Evaluation is based primarily upon the habitat class. "Other" factors will influence final judgment as described in the writeup.

Habitat limiting factors(s) may be detected, or implied, by percentage ratings in habitat categories.

Average depth may be reported as one or several figures for the sample. This statistic helps describe the stream but is not correlated with percent optimum rating.

Presence of rooted (attached) aquatic vegetation substantially increases food production and fish shelter. Total lineal feet of vegetation is to be reported as percent of total width of the sample.

Bank stability is directly related to fish habitat in many instances and is to be reported as percent of station points that are stable. Stable banks, in some instances, provide overhanging bank cover and vegetative root shelter for fish. Unstable banks provide less cover and are a known source of fine sediments, and easily allow channel changes as banks are subjected to natural erosive forces.

Access is recorded as indicated in "Comments" writeup or stream station form. This feature does not affect habitat but does describe potential for use by fishermen.

Water velocity becomes a positive deterring factor when it reaches a point too high to provide rest for trout. Usually, average velocity above 3 feet-per-second is considered too high.

Application of the rating system is described in numerous office reports. An example report is included. (See Appendix-Interstate Highway 70 Location and Salina Creek Aquatic Habitat.)

INSTREAM FLOW

The U.S. Forest Service studied the problem of determining streamflow requirements in the early 1960 period because of the proposed Central Utah Water Development Project. The purposes of the study included a determination of flows necessary to retain aquatic habitat in streams which would be affected upon completion of the various phases of the Central Utah Project.

The science for the determination of instream flow requirements to sustain aquatic life at all seasonal and life history stages is relatively undefined but is under study by several Federal and State agencies.

Various approaches to the problem have been initiated and there is an upsurge of interest for the development of a uniform standard applicable to the needs of all resource agencies involved in water projects.

The procedure developed was a habitat-discharge relationship evaluation used to estimate minimum streamflow to preserve fish habitat values. It was first used to predict habitat retention at low level streamflows on trout streams that range from 4 to 150 feet in width. Procedures were developed through the combined expertise of biologists, hydrologists, and engineers and has been extended to other streams which were subject to storage or diversion on National Forest lands. Most water development projects thus far evaluated have operational release schedules which guarantee water release except during winter or low flow periods which flows usually are subjected to or proposed for total storage or diversion.

Habitat-discharge relationships for all seasonal and life history needs of aquatic organisms should and will be studied.

The habitat-discharge streamflow studies use the transect method to quantify habitat variables and characterize both discharge and channel hydraulic geometry in the manner prescribed as follows.

Sampling is on a stratified random basis along the stream course with channel cross sectioning along one transect at each station. Also, a

hydrograph flow duration curve is prepared from data which is available for gaging stations on the stream course within or directly correlated with study sites.

Results provide acceptably precise habitat and hydraulic feature estimates. Factors such as stream length and width, surface area, pool area, pool cover features and channel location, riffle area, depths, and streambank composition as well as the stability and vegetative cover of the streambanks at known discharge are prepared from the field measurement data. The channel profile features and discharge are computed and discharge can be reported and defined by the percent of time it is equalled or exceeded by interpretation of the flow duration curve.

Habitat is displayed as shown in Figure 1 and data entries are taken from field forms employed in the habitat inventory.

Channel cross sectioning is the procedure by which discharge is measured and a channel profile recorded. The profile is the channel configuration shown in Figure 2 and from which hydraulic geometry features are calculated. Average velocity, depths, width, area, and wetted perimeter are key hydraulic variables of each water stage which are tabulated, Figure 3, and graphically displayed, as in Figure 4, for analysis of habitat retention. It may be necessary to offset upstream or downstream a few feet from the cross section transect for discharge measurements only. This is done when a less irregular cross section is needed for reliable discharge metering.

Discharge is measured using a current meter. Computations are completed in the office and the resulting flow is called the index discharge. It is the rate of flow in cubic feet per second at the sample station at the time of habitat survey. The index discharge information is used to compute estimates of flow at additional water stages by solving Manning's formula for the n fraction: $V = \frac{1.428}{n} X\ r\ 2/3\ X\ S1/2$. "N" thus calculated is then used in computing Q=AV discharge at other water level tracings above and/or below index discharge water level.

For study purposes, the profile is measured along a transect line. Horizontal and vertical distance measurements are taken horizontally along the tapeline and downward to ground level. The profile extends between high watermarks at each bank. The existing water level is noted and depth readings are recorded. The profile is plotted on cross section paper for use in computing rates of discharge and hydraulic geometry. After plotting the profile, the index discharge water level is drawn on the paper. Other water level lines then are drawn above and below the index discharge as in Figure 2 and the investigator calculates discharge and tabulates hydraulic geometry features at the various water levels.

A graph is prepared for each representative cross section as in Figure 4. Points are plotted which represent percent of field measured value for water surface width, wetted perimeter, maximum depth, velocity, and the estimated habitat value for the water stages drawn on drafted cross sections. The graph is a desirable step to visually show intervals between point discharge estimates and the several data points.

The actual field measured values for water surface, wetted perimeter, average maximum depth, and aquatic habitat are reported in the graph legend for the individual stream. Each of these field measured values is the base point indicated as 100 percent at the upper right margin of the graph.

The investigator now has before him the results of the habitat survey and analysis, the index discharge, a channel profile tracing, and a tabulation of hydraulic geometry and discharge at several water levels. It remains to interpret the relationship among and between the several hydraulic variables and to estimate the habitat retention using percentage increments at the several discharges, and to show the data points on graphs as in Figures 4 and 5.

Examples of habitat display are illustrated in Figures 4 and 5.

Two habitat trend lines, labeled A and B, are drawn on the graph of Figure 5. These lines represent two stream habitats and they are the average condition for several cross sections along the two stream courses and such averaging may be done where there is little or no gain or loss in streamflow along the channel. The field measured habitat value is assigned 100 percent and is the point on each line at the graph's upper right hand corner. For line A, at 50 percent of discharge, habitat is estimated as equal to 90 percent of the field measured value. For line B, at 50 percent of discharge, habitat is estimated as equal to 85 percent of the field measured value.

The estimated minimum flows for habitat lines A and B are 50 and 40 percent of discharge, respectively. These were determined as follows.

For line A, the estimated habitat value ranges between 90 and 100 percent of field measured value for discharges between 50 and 100 percent. At 40 percent of discharge, habitat is estimated at 80 percent of field measured value and at 30 percent of discharge, habitat is estimated at 70 percent of field measured value. Therefore, the absolute minimum flow is at 50 percent of discharge, equal to 90 percent of habitat value because of the sharp falloff in value after the 90 percent value.

Line B has uniform slope between 80 and 100 percent of field measured habitat value. Therefore, the most desirable minimum flow is at 40 percent of discharge, equal to 80 percent of habitat value. Discharge equal to 80 percent of field measured habitat value was considered the lowest acceptable rate of flow, although final determination also took into account the rate of change in habitat for percentage units of discharge.

At Montpelier Creek, a determination of discharge gains and losses along the stream course was made. By comparing discharge at two gaging stations, a stage gaging station relationship was computed and accretion flow and discharge probabilities were calculated. Habitat retention was determined independently for each sample station along the stream course and graphically portrayed as in Figure 4.

From inventory work it was concluded that streamflows in c.f.s. of 4, 5, and 6 constituted minimum acceptable flows at key points 1/2 mile, 3 miles, and 5 miles below a proposed storage reservoir. Analysis of streamflow probabilities at the key points resulted in a recommended 4 c.f.s. minimum streamflow 1/2 mile below the damsite, although only 5.2 and 5.6 c.f.s. would be maintained at the other two key points. Description of the Montpelier and Central Utah project streamflow studies are available upon request.

Figure 1 Habitat Analysis for One Sample Station (From Montpelier Creek Study, 1964).

Sample Number	Total Lineal Feet	Percent Bank Stability	Location			Pool Cover Feature			Rating		Habitat Analysis				
			Bank	Entire	Center	Vetetation	Depth	Boulder	1,2,3,4,5		Pool Measure	Pool Structure	Stream bottom	Stream Environment	Percent of Optimum
1	65	90	3	15	8	18	8	0	26	0	80	80	45	70	69

Figure 2. A Profile

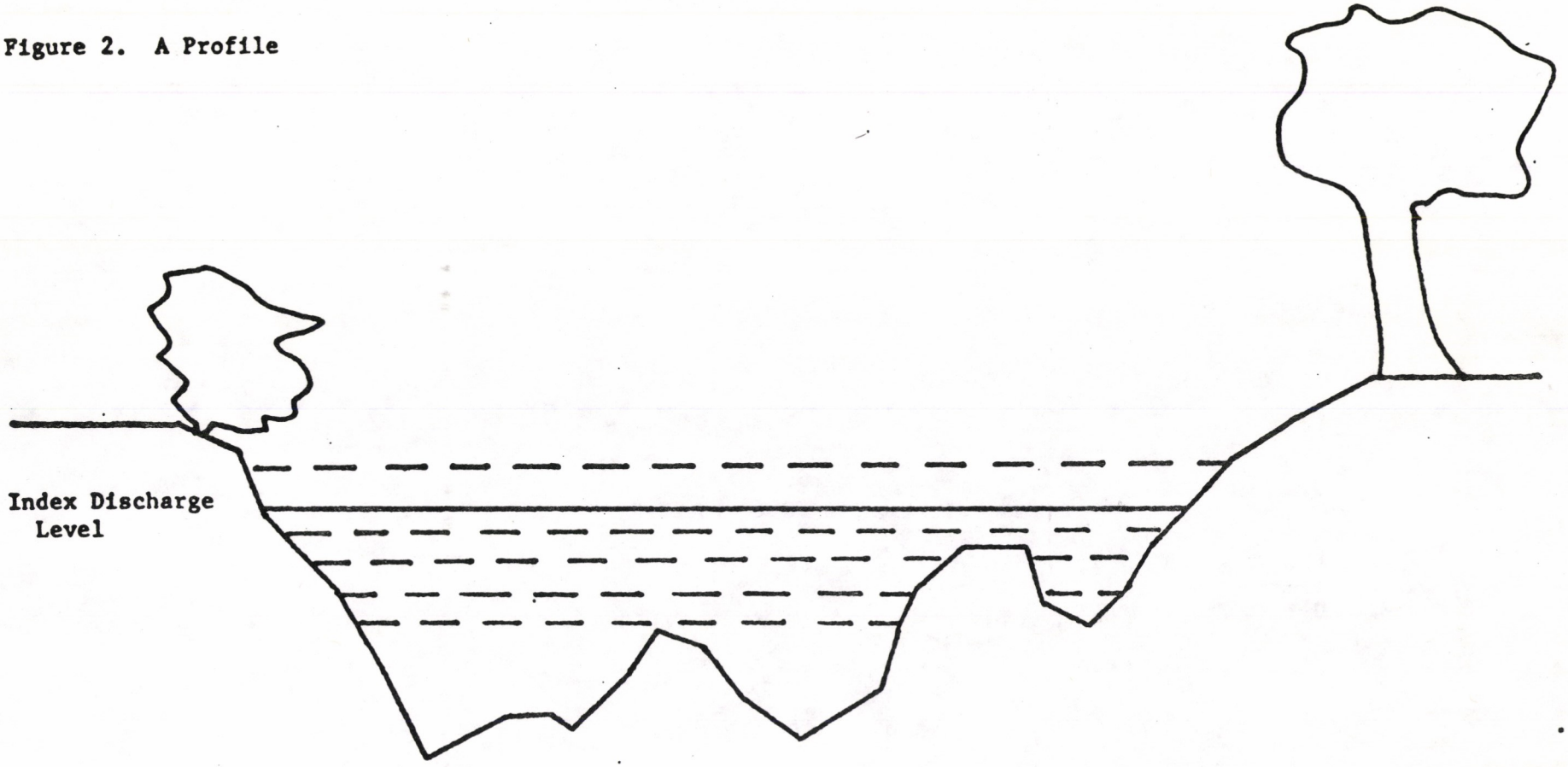


Figure 3. Tabulation of Cross Section Data (From Montpelier Creek Study, 1964).

Sample Number	Water Level Number	Wetted Perimeter	Surface Width	Maximum Depth	Cross Section Area	Slope	Manning's Formula N Factor	r 2/3	S ½	Velocity of Flow	Discharge	Percent Habitat Retention
1	1	12.5	12.0	1.425	10.13	.014	.102	.869	.1183	1.5	15.2	100
	2	11.3	10.9	1.225	7.83	"	"	.784	"	1.4	11.0	100
	3	10.0	9.6	1.025	5.81	"	"	.696	"	1.2	7.0	75
	4	8.8	8.5	0.825	4.07	"	"	.597	"	1.0	4.1	75
	5	6.7	6.5	0.625	2.32	"	"	.493	"	.9	2.1	50
	6	5.5	5.5	0.425	1.33	"	"	.388	"	.7	.9	25

Figure 4. Selected hydraulic variables at representative cross section.

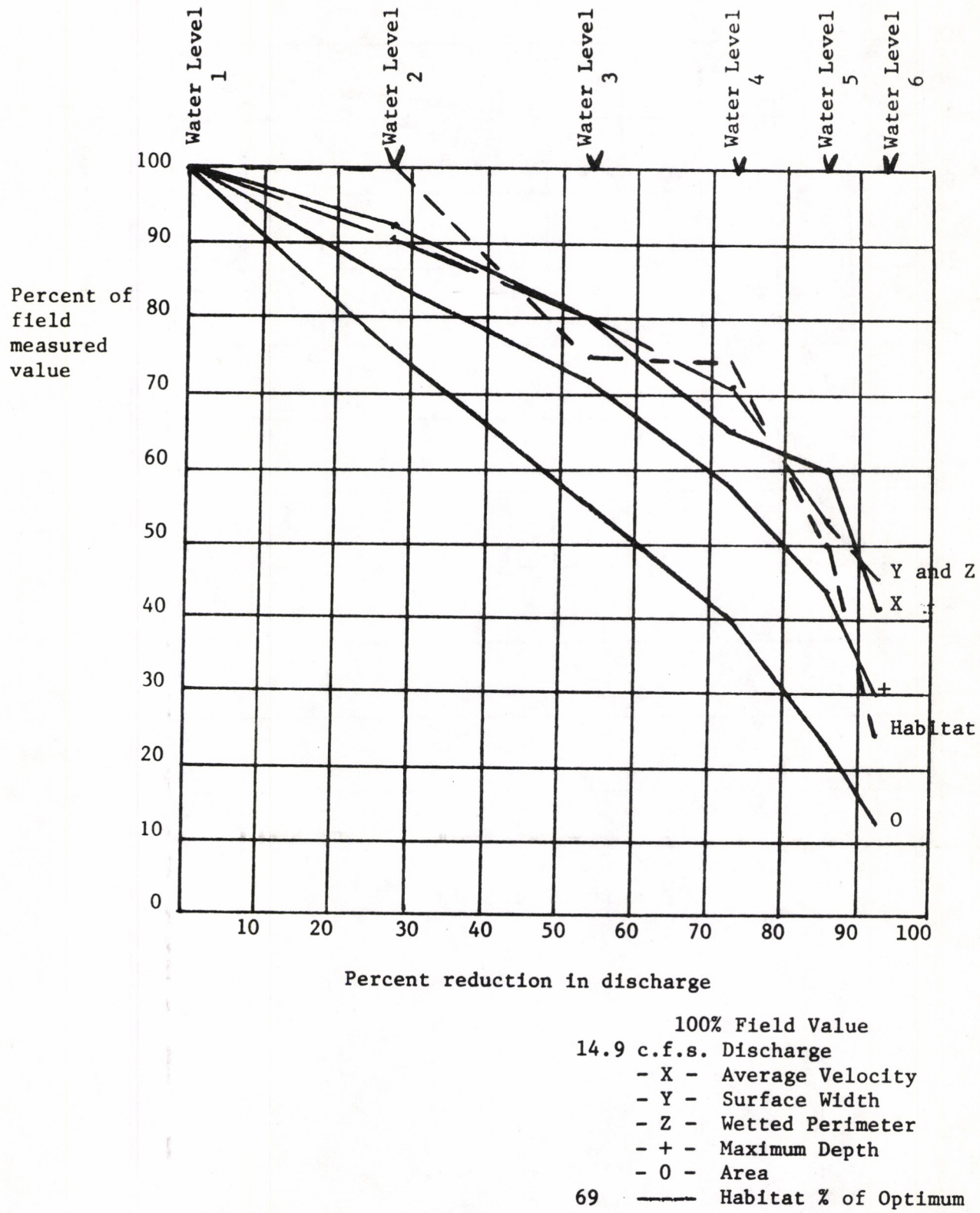
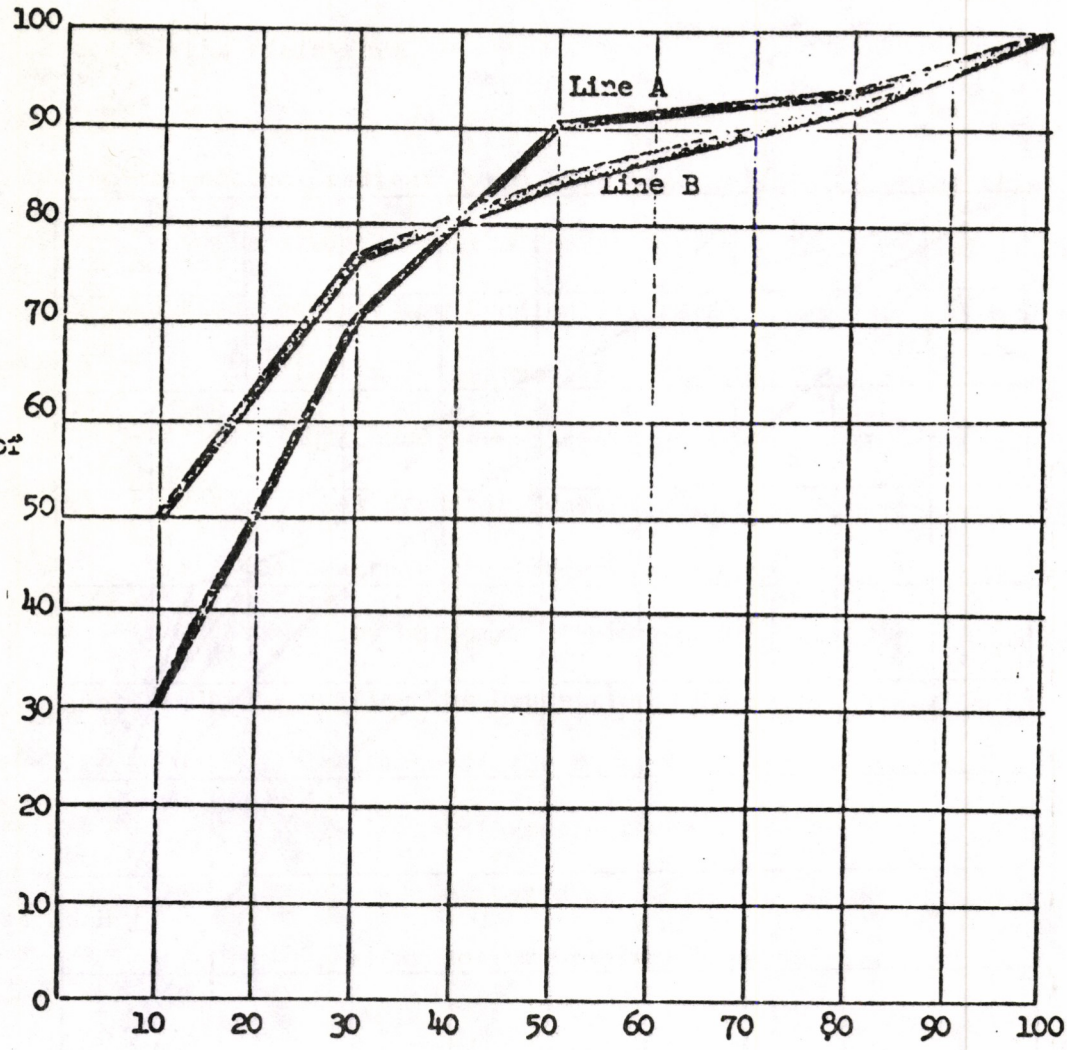


Figure 5 illustrates the estimation of minimum flow by the graphic representation of habitat data.

Figure 1.



GRADIENT STRATIFICATION FOR LAND USE PLANNING AND CONCEPT OF THE VALLEY BOTTOM HABITAT TYPE

The objective of this approach is to stratify the valley bottom into identifiable units of land that are mappable, describable, and predictable. These units of land are easily recognizable by the land manager as well as the fishery biologist or to anyone else relating to the habitat within the valley bottom. The system is flexible enough to handle large acreages of land using a limited inventory or smaller areas with an intensive inventory.

The real value in this system to the fishery biologist is the similarity of the aquatic habitat found in each valley bottom gradient type within a stream or between streams. Although there are some differences in the aquatic habitat from one area to another within a given gradient type, the relationships are great enough for general land use planning purposes. This system further provides a unit of land that can be divided into smaller units or described as a subunit of a particular gradient type as additional data becomes available.

The basic data for this system is collected using the "Transect Method." Additional parameters include the measurement of the valley bottom width and the percent of the slopes leaving the valley bottom.

The valley bottom is described as that area of land that has been formed as a result of water related processes, glacial activity and may be influenced by the present stream.

In many cases, it will be from toe slope to toe slope. The measurement is made to the nearest 10 feet, excluding the channel width.

A cross-section of the valley bottom at each station is sketched on the backside of the field form.

Three Valley Bottom Gradient Types have been delineated using this system. There is evidence that a fourth type should be included. The three types described are Low Gradient, Intermediate Gradient, and Steep Gradient. Low Gradient and Intermediate Gradient Types are located primarily in lands that have been classified as Depositional Lands by the soil scientist. Low Gradient Types are located almost always in the wide valley bottoms; whereas the Intermediate Gradient Types are located in the narrow-open valley bottoms. The Steep Gradient Type is located with few exceptions outside the Depositional Lands. Further field investigations will determine if the Steep Gradient Type should be divided into two types. Field investigations indicate that gradient is the key parameter needed to delineate these types. Other parameters help substantiate the Valley Bottom Gradient Type concept.

Each gradient type offers certain management capabilities. Forest activities that may take place within a given type include road construction, bridge and culvert location and construction, grazing and recreational sites. A given forest activity may be compatible with one type and not another. (See Appendix - A Systematic Approach to the Stratification of the Valley Bottom Gradient Type.)

This systematic approach to the stratification of the Valley Bottom Type offers the fishery biologist a unit of land that is easily related to. Most important, it offers the land manager an identifiable unit of land with capabilities to help in making sound management decisions.

The approach used in this system is based upon limited data; however, the data does indicate that a segment of one stream does contain a similar aquatic habitat as that found in a similar segment in another stream. There are strong implications that these gradient types have certain management capabilities and can be managed as separate units of land. Such an approach offers the biologist enough data for present land use planning levels and a base that can be built upon as more data becomes available without changing to a new system.

STRATIFIED RANDOM FOR BASE INVENTORY

Random stratification using 1-mile intervals has been in effect since initial testing of the habitat inventory. The field data collected is summarized, analyzed, interpreted and reported with recommendations. Less than 1-mile intervals are used on stream courses of short length when regular 1-mile intervals would result in too few samples. (See Appendix - Aquatic Habitat Inventory and Appraisal Fifth Water, Sixth Water, and Diamond Fork below Three Forks.)

CONCLUDING COMMENTS

The use of transect inventory procedures has provided the habitat biologist with new sets of data. The incorporation of water cover features, streambottom descriptions, and streambank measurements into a resource data base, in a systematic way, has provided reliable and predictable measures of land use and other project impacts on the aquatic habitats. The precision and accuracy in measuring and analyzing habitat features thus gained particularly benefits land managing agencies where wildlife decisions will be given the added safeguard and benefit of habitat documentation.

Good results have been achieved in applying this methodology in the U.S. Forest Service, Intermountain Region. Additionally, interagency agreements have extended the work to other Federal and State agency jurisdictional areas closely allied with National Forests.

We anticipate continued interest in habitat inventories and the evolution of greater precision and accuracy in estimating habitat correlation to other abiotic and biotic features as well.

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APPENDIX

AQUATIC HABITAT INVENTORY

COMPUTER STORAGE PROGRAM

GUIDELINES

These are interim Guidelines Subject to
Change as the program is fully reviewed.

ALBERT COLLOTZI
Fishery Biologist
Bridger-Teton National Forest
April 25, 1975

FOREWARD

The Bridger-Teton National Forest will be using this program as outlined during all field surveys in 1975 or until a final product is available. Although there may be changes in the total approach, our Forest will have the data available and ready for the program.

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III.	STREAM STATION	3
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	B. Card Codes 3-7	11

I. INTRODUCTION

This computer program provides the fishery biologist with the opportunity to store aquatic habitat inventory data. Once this data has been stored it can be manipulated using various programs already developed for the computer or it can be recalled as it was placed in the computer for later reference. Naturally the value of the output information is directly proportional to the quality of the raw data input. It is absolutely necessary for neatness and accuracy on the data format forms.

There are two separate forms which are used for this program. One form, the Stream Identification Form, is used for each stream and can be filled out in the office. The second form, the Stream Station Form, is to be used for each station on the stream, and has been designed for use in the field. If used properly, the forms can be photocopied and the copy sent to the computer center. The original is to be filed with your records.

II. STREAM IDENTIFICATION

The Stream Identification Form has been designed to identify a given stream to the computer. Information on this form occupies one card of 80 spaces. This form can be completed in the office. The items on this form need to be completed as follows:

Item 1 - Space 1 - Card Code

This item requires no entry

Stream Aquatic Habitat Inventory
(Coded for Computer)

Print or Type

STREAM IDENTIFICATION FORM

Stream _____ Forest _____

Date _____ Investigator _____

1 - Card Code 1 (1)

2 - State . (2 3)

3 - Forest . (4 5)

4 - Catalog No. . . . . (6 19)

5 - Location: Longitude . . . . (20 24) Latitude . . . (25 28)

6 - Total Length . . . (29 32)

7 - Stream Order . (33.34)

8 - Name of Stream . . . . . (35 57)

. . . . . (58 80)

STREAM AQUATIC HABITAT INVENTORY
(Coded for Computer - Print or Type)
Stream Station Form

USDA Forest Service

Stream _____ Forest _____

Date _____ Investigator _____

Card Code 2/1 Photo No. _____

48 A

1 - State ___ (2 3) 2 - Forest ___ (4 5) 3 - Catalog # _____ (6 19) 4 - Date of Sample ___ (20 23) 5 - Station No. ___ (24 26)

6 - Location: Long. ___ (27 31) Lat. ___ (32 35) 7 - Sample No. ___ (36 37) 8 - Gradient ___ (38 39) 9 - Velocity ___ (40 42) 10 - Volume cfs ___ (43 47)

11 - Valley Bottom Width ___ (48 51) 12 - Beaver ___ (52) 13 - State Class ___ (53) 14 - Fishery ___ (54 58) 15 - Endangered-Threatened Species ___ (59 61)

16 - Invert.: grms/meter sq. ___ (62) Div. Index ___ (63) 17 - Geologic Class ___ (64) 18 - Geology ___ (65) 19 - Access ___ (66) 20 - Temp.: Air ___ (67 68) Water ___ (69 70)

21 - Time of Day ___ (71 74) 22 - Elevation ___ (75 79)

	WATER SURFACE																STREAM BOTTOM							BANK MEASUREMENT	
					POOLS																			Left Bank	Right Bank
			0.00		1				2				3												
CODE CARD	Channel Width	Water Width	Average Width	Riffle Width	Pool Width	Rating	Location	Feature	Pool Width	Rating	Location	Feature	Pool Width	Rating	Location	Feature	Aquatic Plants	12+	6 - 12 3 - 6	1 - 3 1/8 - 1	Sand	Silt	Type	Other	Envir. / Stab.	Envir. / Stab.
1	20. .23	24. .26	27. .29	30. .32	33. .35	36	37	38.39	40. .42	43	44	45.46	47. .49	50	51	52.53	54. .56	57. .59	60. .62	63. .65	66. .68	69. .71	72	73. .75	76 / 77	78 / 79
3	. . .	. .	. .	. .	. .			.	. .			.	. .			.	. .	. .	. .	. .	. .	. .		. .	. / .	. / .
4	. . .	. .	. .	. .	. .			.	. .			.	. .			.	. .	. .	. .	. .	. .	. .		. .	. / .	. / .
5	. . .	. .	. .	. .	. .			.	. .			.	. .			.	. .	. .	. .	. .	. .	. .		. .	. / .	. / .
6	. . .	. .	. .	. .	. .			.	. .			.	. .			.	. .	. .	. .	. .	. .	. .		. .	. / .	. / .
7	. . .	. .	. .	. .	. .			.	. .			.	. .			.	. .	. .	. .	. .	. .	. .		. .	. / .	. / .

COMMENTS _____

Sketch cross section of valley bottom on reverse side and show % slopes above valley bottom.

POOL RATING GUIDE

Pool rate	Pool length or width	Pool depth	Pool shelter* (cover)
1	Greater than av. stream width	2' or deeper	Abundant 1/
	Greater than av. stream width	3' or deeper	Exposed 2/
2	Greater than av. stream width	2' or deeper	Exposed
	Greater than av. stream width	-2'	Intermediate 3/
	Greater than av. stream width	-2'	Abundant
3	Equal to average stream width	-2'	Intermediate
	Equal to average stream width	-2'	Abundant
4	Equal to average stream width	Shallow 4/	Exposed
	Less than average stream width	Shallow	Abundant
	Less than average stream width	Shallow	Intermediate
	Less than average stream width	-2'	Intermediate
	Less than average stream width	+2'	Abundant
5	Less than average stream width	Shallow	Exposed

*Shelter = Logs, stumps, boulders in or overhanging pool. Dense beds of aquatic vegetation or overhanging banks.

1/ Abundant = More than 1/2 perimeter of pool has cover.

2/ Exposed = Exposed (little or no shelter or cover) less than 1/4 of pool perimeter has cover.

3/ Intermediate = 1/4 to 1/2 perimeter of pool has cover.

4/ Shallow = Approximately equal to average stream depth.

KEY FOR FILLING OUT FRONT OF FORM

Item 11 - Beaver Influence

1 - Active beaver dams present.
2 - Inactive or old beaver dams present, but in good condition.
3 - Inactive or old beaver dams present, but in poor repair.
4 - No beaver activity present.

Item 17 - Geology Landform

Landform	Valley Bottom Material
1. U-shaped valley	moraine
2. U-shaped valley	alluvium
3. U-shaped valley	bedrock
4. V-shaped valley	moraine
5. V-shaped valley	alluvium
6. V-shaped valley	bedrock
7. planar landform	moraine
8. planar landform	alluvium
9. planar landform	bedrock

Item 18 - Access

1. satisfactory for modern car
2. not too good, but can be reached by car
3. jeep, horseback or foot
4. horseback or foot on trail
5. no trails

Code Cards 3 through 7

Pool Rating:

Pool Location: 1-right bank 2-left bank 3-center if not bank associated

Pool Features: 1-boulder 2-overhanging bank 3-water depth 4-vegetation or tree roots 5-log jam 6-beaver dam 7-rock outcrop 8-surface turbulance and velocity 9-other

Type-space 72: 1-badrock 2-sunken log 3-decaying vegetable matter 4-other

Environment-space: 1-forested 2-brush 3-exposed

Stability-space: 1-stable 2-unstable

Use this space to sketch cross section of valley bottom.

Item 2 - Spaces 2 & 3 - State

The accepted Federal coding for States is as follows:

06 California	49 Utah
16 Idaho	56 Wyoming
32 Nevada	

Item 3 - Spaces 4 & 5 - Forest

The National Forest Coding for this Region.

01 Ashley	08 Fishlake	15 Targhee
02 Boise	09 Humboldt	17 Toiyabe
03 Bridger-Teton	10 Manti-LaSal	18 Uinta
05 Caribou	12 Payette	19 Wasatch
06 Challis	13 Salmon	
07 Dixie	14 Sawtooth	

Item 4 - Spaces 6-19 - Catalog Number

The catalog number for any given stream is that used by the State. Place the catalog number to the far left and leave the remaining spaces blank. Using this number will provide for an exchange of data between the Forest and the State.

Item 5 - Spaces 20-28 - Location

This item will locate the stream at its mouth or at the Forest boundary.

Item 6 - Spaces 29-32 - Total Length

Enter the total length of the stream located within the Forest boundary.

Item 7 - Spaces 33 & 34 - Stream Order

Enter stream order as identified by hydrologist.

Item 8 - Spaces 35-80 - Name of Stream

List the name of the stream if available.

III. STREAM STATION

The Stream Station Form has been designed for use in the field. (Figure 2) Information on this form occupies six cards of 80 spaces each to be used in the computer center. The first card has to do with measurements or observations that are made only once at each station. The remaining five cards are for each of the five transect lines to be measured at the station. The data to be collected along the transects are as described in the manual for stream habitat survey and analysis with a few modifications. The items on this form need to be completed as follows:

A. Card Code #2

Item 1 - Spaces 2 & 3 - State

The accepted Federal coding for States is as follows:

06 California	49 Utah
16 Idaho	56 Wyoming
32 Nevada	

Item 2 - Spaces 4 & 5 - Forest

The National Forest Coding for the Region.

01 Ashley	08 Fishlake	15 Targhee
02 Boise	09 Humboldt	17 Toiyabe
03 Bridger-Teton	10 Manti-LaSal	18 Uinta
05 Caribou	12 Payette	19 Wasatch
06 Challis	13 Salmon	
07 Dixie	14 Sawtooth	

Item 3 - Spaces 6-19 - Catalog Number

Same as Item 4 under Stream Identification.

Item 4 - Spaces 20-23 - Date of Sample

Enter month and year of sample.

Item 5 - Spaces 24-26 - Station Number

Enter station number in spaces 24 and 25. Space 26 is reserved for nine more stations between each regular station. This allows for greater detailed analysis at the project level. These extra stations would be recorded as 09.1, 09.2, etc. This will require preplanning for every stream prior to sampling.

Item 6 - Spaces 27-35 - Location

Give the location of the station as close as possible by longitude and latitude.

Item 7 - Spaces 36 & 37 - Sample Number

The first time a station is sampled the sample number would be 01, the next time it would be 02, etc.

Item 8 - Spaces 38 & 39 - Gradient

Record gradient to the nearest one-half percent.

Item 9 - Spaces 40-42 - Velocity

Space 40 is reserved for number 1 if measured with equipment or number 2 if estimated. The velocity is recorded in spaces 41 and 42.

Item 10 - Spaces 43-47 - Volume

Record in C.f.S. to nearest whole number.

Item 11 - Spaces 48-51 - Valley Bottom Width

The valley bottom is described as that area of land that has been formed as a result of water-related processes, glacial activity, and may be influenced by the present stream. In many cases it will be from toe slope to toe slope. The measurement is to be made to the nearest 10 feet, excluding the channel width.

Item 12 - Space 52 - Beaver influence

Place in the space the number corresponding to the situation.

1 - Active beaver dams present.
2 - Inactive or old beaver dams present, but in good condition.
3 - Inactive or old beaver dams present, but in poor repair or they are of no effect upon the fishery.
4 - Evidence of old beaver dams, but little affect upon the present stream.
5 - No beaver activity present.

Item 13 - Space 53 - State Stream Classification

Most States have given fishery streams a classification based upon the productivity of the stream along with other items such as access and aesthetics. If the classification is available, record it in this space.

Item 14 - Spaces 54-58 - Fishery

Starting from the left record the most dominant or important fish species using the corresponding letter.

A.	Rainbow Trout	N.	
B.	Cutthroat Trout	O.	
C.	Brown Trout	P.	
D.	Brook Trout	Q.	
E.	Lake Trout	R.	
F.	Salmon (Anadromous)	S.	
G.	Salmon (Kokanee)	T.	
H.	Steelhead Trout	U.	
I.	Golden Trout	V.	
J.	Whitefish	W.	
K.	Grayling	X.	
L.		Y.	
M.		Z.	

Item 15 - Spaces 59-61 - Endangered-Threatened Species

Space 59 is reserved for the specific classification of the specie. Spaces 60 and 61 are reserved for up to two species.

Specific Classification	Species
Federal	A - Lahontan Cutthroat
1 - Endangered	B - Paiute Cutthroat
2 - Threatened	C - Humpback Chub
State	D - Kendall Warm Springs Dace
3 - Rare	E - Colorado River Squawfish
4 - Peripheral	F - Woundfin
5 - Endangered	G - Arctic Grayling
6 - Status Undetermined	H - Humboldt Cutthroat
Other	I - Colorado Cutthroat
7 - Unique	J - Utah Cutthroat
	K - Snake River Cutthroat
	L - Sacramento Perch
	M - Other

Item 16 - Spaces 62 & 63 - Invertebrates

Two items are entered on the form. These are weight per cubic meter of organisms and a diversity index. Most streams

may not have this information for some time. The data to be collected, analysis work, and entries at Item 16 will be described in water quality surveillance guidelines. Enter the letter which corresponds to your results.

Macroinvertebrate Standing Crop

Scale		gm/m^3
A=0		
B=1	High	10-15
C=2		
D=3	Average	5-9
-		
-		
-	Low	0-4
-		
Z=25		

Macroinvertebrate Diversity Index

(based upon 40 taxa)

	Stream Condition	SCI_t
A=0		
B=1		
C=2	Excellent	18-30
D=3		
	Good	11-17
-		
-		
-	Fair	6-10
K=10		
-		
-	Poor	0- 5
-		
P=15		
-		
-		
-		
U=20		
V=22		
W=24		
X=26		
Y=28		
Z=30		

Item 17 - Space 64 - Geologic Classification
Developed by Oakes & Glenn

The data for this space is available from the soil scientist, geologist or a good geology map and can be entered later in the office after the field work is completed. The classification is based on the geologic material above the sample point. In order to use this system, you will need to understand the following definitions:

Granite: Includes all pre-Cambrian rocks - chiefly granite, but also includes metasedimentary rocks (gneiss & schist). Produces coarse sediments.

Hard Sedimentary: Paleozoic rocks. Well consolidated, contains high proportion of hard sandstone, limestone, and dolomite. Not high sediment producers.

Soft Sedimentary: Mesozoic and Cenozoic rocks. Poorly consolidated, high frequency of mass movement. Contains many soft plastic shales. High sediment producers - much suspended sediment.

Flows: (Basalt-rhyolite, etc.) Fine grained igneous rocks occurring in large sheets.

Select the category which best fits the situation and place the letter in the space.

Primary	Dominant Secondary
A-Granite-100%	None (may allow 10% inclusions)
B-Granite->50%	Hard Sedimentary <50%
C-Granite->50%	Soft Sedimentary <50%
D-Granite->50%	Flows (lava, rhyolite, etc) < 50

Primary	Dominant Secondary
E-Hard Sedimentary-100%	None (10% inclusions OK)
F-Hard Sedimentary- >50%	Granite- <50%
G-Hard Sedimentary- >50%	Soft Sedimentary- <50%
H-Hard Sedimentary- ≥50%	Flows- <50%
I-Soft Sedimentary-100%	None (10% inclusions OK)
J-Soft Sedimentary- >50%	Granite- <50%
K-Soft Sedimentary- ≥50%	Hard Sedimentary- <50%
L-Soft Sedimentary- ≥50%	Flows- <50%
M-Flows-100%	None (10% inclusions OK)
N-Flows- ≥50%	Granite- <50%
O-Flows- ≥50%	Hard Sedimentary- <50%
P-Flows- ≥50%	Soft Sedimentary- <50%

Item 18 - Space 65 - Geology Landform

While at the station try to determine the geology landform as described below. If this becomes difficult, record comments and discuss with a soil scientist or geologist upon returning from the field. Select the process which best describes the situation and record the number in the space.

Landform	Valley Bottom Material
1. U-shaped valley	moraine
2. U-shaped valley	alluvium
3. U-shaped valley	bedrock

	Landform	Valley Bottom Material
4.	V-shaped and open valley	moraine
5.	V-shaped and open valley	alluvium
6.	V-shaped and open valley	bedrock
7.	planar landform	moraine
8.	planar landform	alluvium
9.	planar landform	bedrock

Item 19 - Space 66 - Access

Select the criteria that best describes the situation and record the number.

1. Access is satisfactory for modern car.
2. Access is not too good, but can be reached by car.
3. Accessible road or trail is fit or appropriate for jeep, horseback or foot.
4. Accessible trail for horseback or foot.
5. No trails to area.

Item 20 - Spaces 67-70 - Temperature

Record in spaces 67 and 68 the air temperature at the time of sampling in degrees Fahrenheit. In spaces 60 and 70 record the water temperature at the time of sampling in degrees Fahrenheit.

Item 21 - Spaces 71-74 - Time of Day

Record in military time the time of day temperatures are being taken.

Item 22 - Spaces 75-79 - Elevation

Can be taken from topographic map or measured with a pocket altimeter.

B. Card Codes 3 through 7

Items 1, 2 and 3 are the same as Card Code 2 and will be repeated only at the computer center. These cards will begin with space 20. This section has to do with measurements that are repeated from transect to transect. All measurements are made as described in the manual. Only two major changes have been made from that in the manual. These are the separation of sand and silt measurements and the elimination of Class under bank measurements.

This section is also coded for the computer and where words were used in a space in the past, a number must be used, such as pool location and feature, type of other under stream bottom and environment and stability under bank measurement. Although these parameters and numbers are listed in this write-up, they are also listed on the back of the Stream Station Form for use in the field.

Unless there is a need for a parameter to be converted to a number it will not be discussed. Parameters will be discussed from left to right.

Average depth - record to nearest tenth of a foot. Examples 16.2, 3.0, etc.

A SYSTEMATIC APPROACH TO THE STRATIFICATION OF THE VALLEY BOTTOM GRADIENT HABITAT TYPE

BY

ALBERT W. COLLOTZI
FISHERY BIOLOGIST
BRIDGER-TETON NATIONAL FOREST

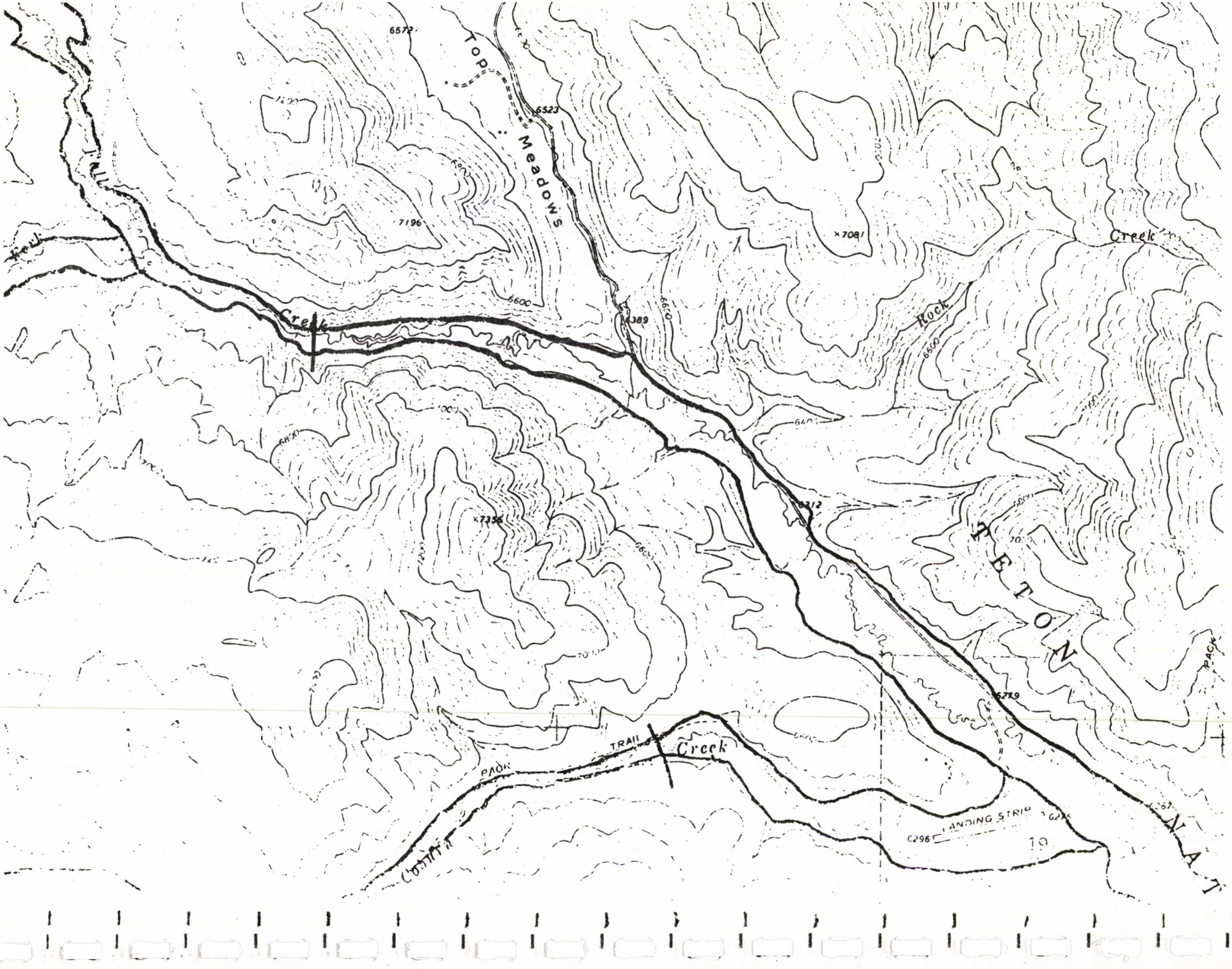
Introduction

The fishery biologist is continually searching for a more effective method to stratify the aquatic habitat. The approach presented in this paper is not perfect, but it does present a classification that is easily identifiable by the fishery biologist and the land manager.

During 1974 three planning units were programmed for inventory covering nearly one million acres. These planning units contained 154 trout streams with a total length of approximately 964 miles. No habitat data was available for these streams and other fishery information was limited. The problem was how to handle such a large inventory using some systematic approach and, at the same time, provide the land manager with useable information.

A Systematic Approach

Streams on the planning units were premapped during March and April. Premapping included the reviewing of resource photographs (1:1584) for each planning unit and the outlining of the valley bottoms on Geological Survey Maps (7.5 minute series - topographic) (Fig. 1). These valley bottoms were then separated into segments containing what looked


Top
Meadows
Creek
Rock
Creek
Creek
TETON
TRAIL
PACK
PACK
TRAIL
Creek
LANDING STRIP
10
A.T.
6523
6600
6650
6389
6312
6279
6296
7196
7081
7356

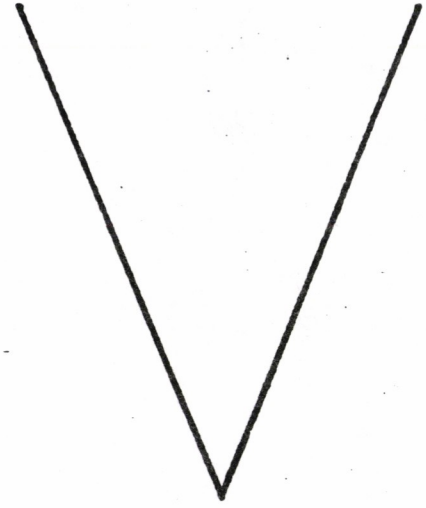
to be similar habitat, the basic assumption being that a segment of one stream would contain the same habitat as a similar segment in another stream. In order to confirm this basic assumption, nearly all segments within each stream had to be sampled.

Due to the size of acreage in the planning units, it was obvious that a detailed approach could not be used to stratify the habitat in detail as done by Platts on the upper south fork of the Salmon River (Platts, 1974). It was decided to use a system that would allow stratification on a broad basis. The idea was to classify the valley bottoms into three types (V-shaped, narrow-open, wide bottoms) (Fig. 2). The V-shaped valleys would be located in other than Depositional Lands (Landtype Association Classification), whereas the narrow-open valleys would be located primarily in Depositional Lands not covered in the Landtype Association map because of their small size. The wide valleys would fall within the Depositional Lands as mapped by the soil scientist. It was also assumed that all streams having an overall cutting action would be located in the V-shaped valley bottoms. This type of system would result in all streams in the V-shaped valleys having a high percentage of boulder in the stream bottom composition and a very small percentage of boulder in streams located in Depositional Lands (Fig. 3). Other components of the stream bottom composition would fall about as shown in Figure 3.

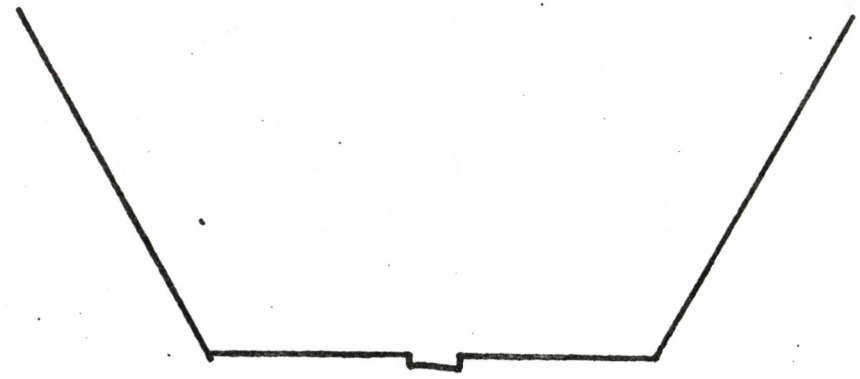
Method

During the summer of 1974 nearly all of the 154 trout streams

VALLEY BOTTOM TYPES



V-SHAPED BOTTOM



NARROW-OPEN BOTTOM

WIDE BOTTOM

FIGURE 2

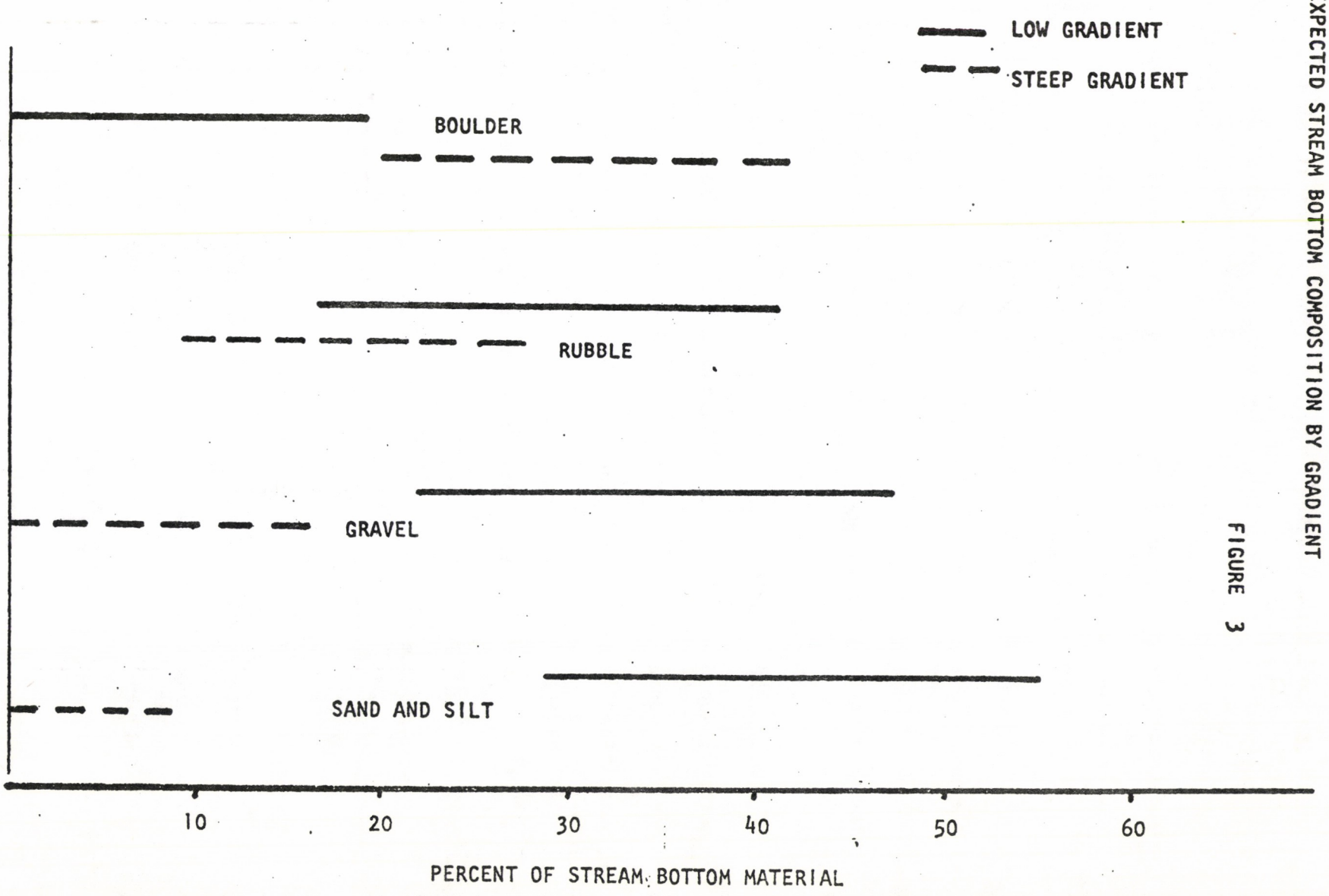


FIGURE 3

EXPECTED STREAM BOTTOM COMPOSITION BY GRADIENT

were visited by the author. In addition a majority of the 964 miles of stream were either walked or driven. Most of the actual data was collected by two summer people using the Transect Method as outlined by Herrington and Dunham (1967). Additional information collected included a sketch on the back of the field form illustrating the valley bottom. Sample stations were predetermined prior to going into the field. At least one station was located within each delineated stream segment as marked on the Geological Survey Maps during the premapping. Additional information was collected between many of the above stations on a modified form. Extra photographs were taken along each stream and marked for reference to be used at a later date.

Nearly 200 stations were sampled during 1974 using the transect method. Approximately 100 other stations were sampled using the modified form. The data from these stations was used to develop the stratification of the Valley Bottom Habitat Type as presented in this report.

After the field season all data was analyzed and used to prepare the fishery resource inventory for each planning unit. A map was produced for each unit showing the habitat types for streams sampled.

Results

Indications are that most of the basic assumption, (that a segment of one stream contains the same habitat type as a similar segment in another stream) is true. However, several problems did arise that were not expected.

1. Not all streams were depositing material in lands classified as Depositional Lands by the soil scientists.
2. The stream bottom composition varied between streams located in soils of sedimentary origin and granitic origin.
3. The bottom composition created by beaver dams did not fit in the present habitat types.
4. The pool-riffle relationship between stream segments of different streams varied considerably, but the relationship within a stream was similar.

While working on the Greys River it was observed that the overall action of the river in some areas was one of cutting. However, nearly all of the lands surrounding the Greys River (valley bottom) had been classified as Depositional Lands. The soil scientists had classified these lands as such based on earlier depositional processes. At the present time the Greys River is cutting through areas of earlier deposition. This same situation was also evident in several other streams sampled during the year. Although the overall action of these stream segments is one of cutting the aquatic habitat looked to be different that that found in the V-shaped valleys. As a result, these stream segments were treated as a separate Habitat type.

During the analysis of the data (stream bottom composition) of streams on the West Slope Planning Unit, it was observed that the results did not fit with that of the Greys-Salt River Planning Unit. However, streams from the northern end of the West Slope Planning Unit did fit with the streams from the Greys-Salt River Unit. After

reviewing the data for some time it was discovered that only those streams originating in granitic soils and parent material were different from the streams located in the Greys-Salt River Unit (fig. 4, 5, 6). All of the streams located in the Greys-Salt River and the northern end of the West Slope Planning Units originate in sedimentary soils and parent material. The main differences are in the larger percent of boulder, smaller percent of rubble and the larger percent of coarse sand found in the bottom composition of streams flowing from granite parent material.

Bottom composition of beaver dams do not fit in the present Habitat Types and should be treated as a sub-unit of the Habitat Type.

During the analysis of the data collected from the sample stations it was evident that there was a lack of correlation between some parameters. The most consistent of these parameters was the pool-riffle relationship. However, within a given stream the pool-riffle relationship is quite consistent between similar segments.

During the review of the data, as well as onsite investigations, it became evident that each of these Habitat Types offer certain management capabilities. Forest activities that may take place within a given Habitat Type include road construction, bridge and culvert location and construction, grazing and recreational sites. A given forest activity may be compatible with one habitat type and not another.

FIGURE 4

BOTTOM MATERIAL COMPOSITION OF THE STEEP GRADIENT HABITAT TYPE BY SOIL PARENT MATERIAL

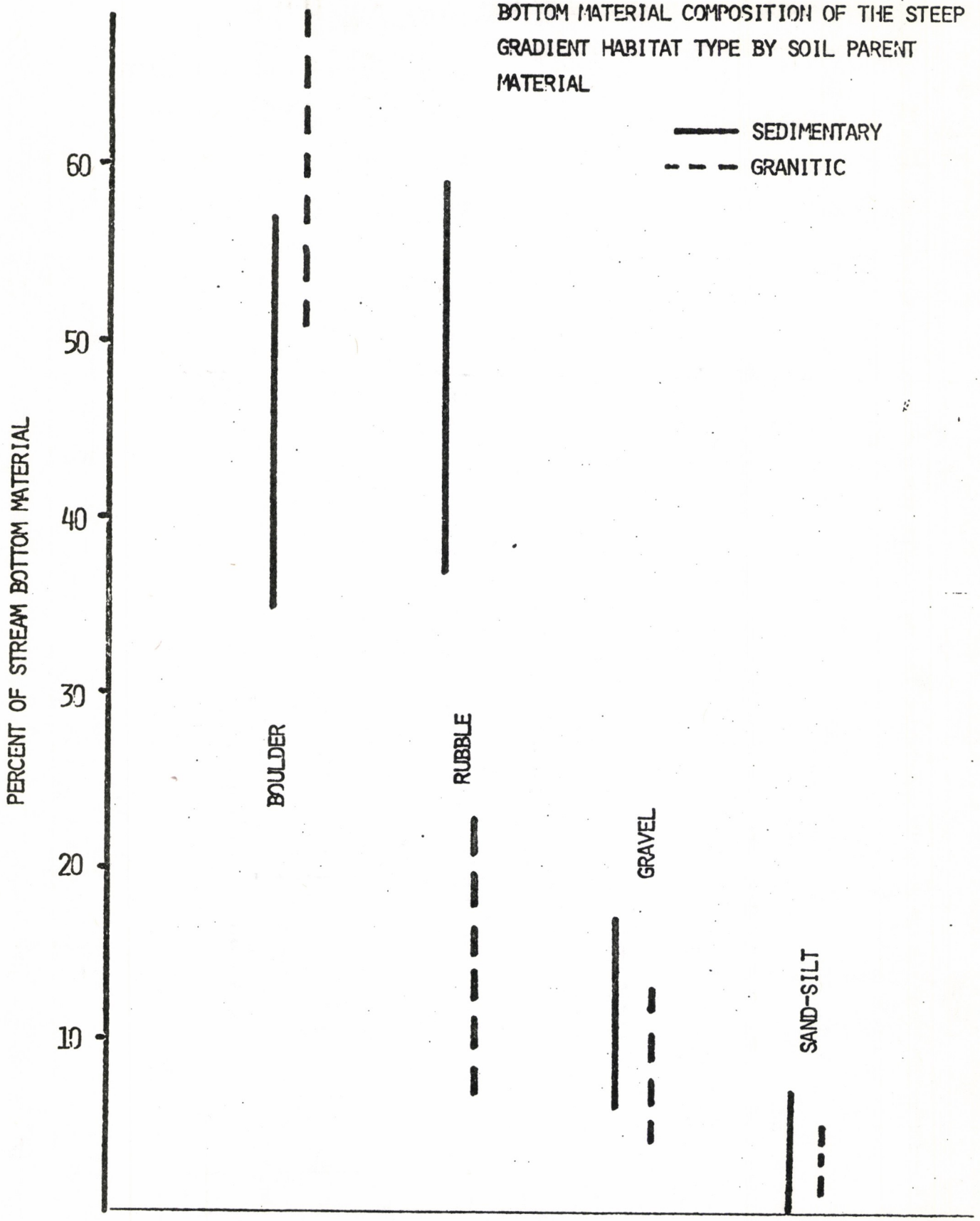


FIGURE 5

BOTTOM MATERIAL COMPOSITION OF THE INTERMEDIATE GRADIENT HABITAT TYPE BY SOIL PARENT MATERIAL

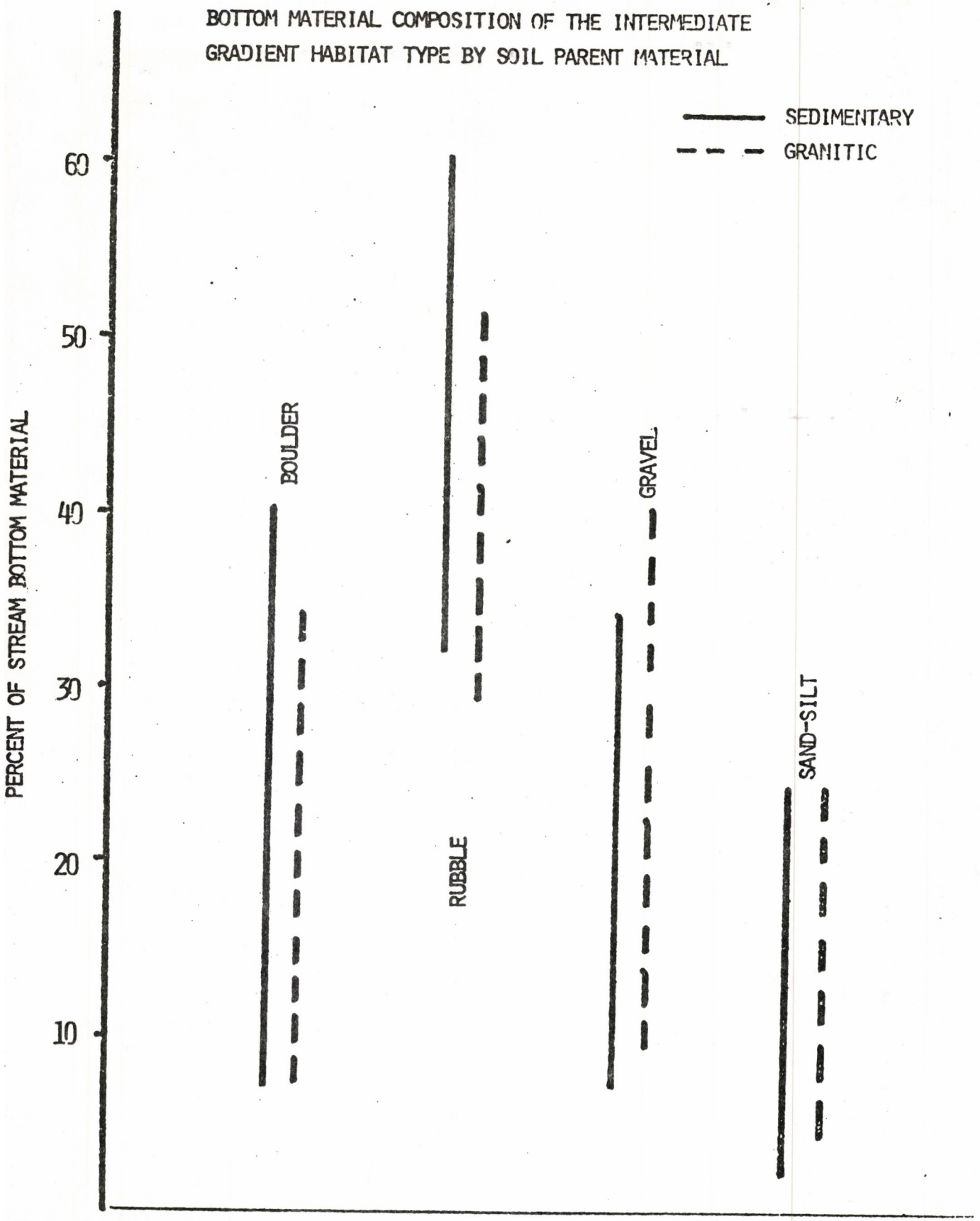
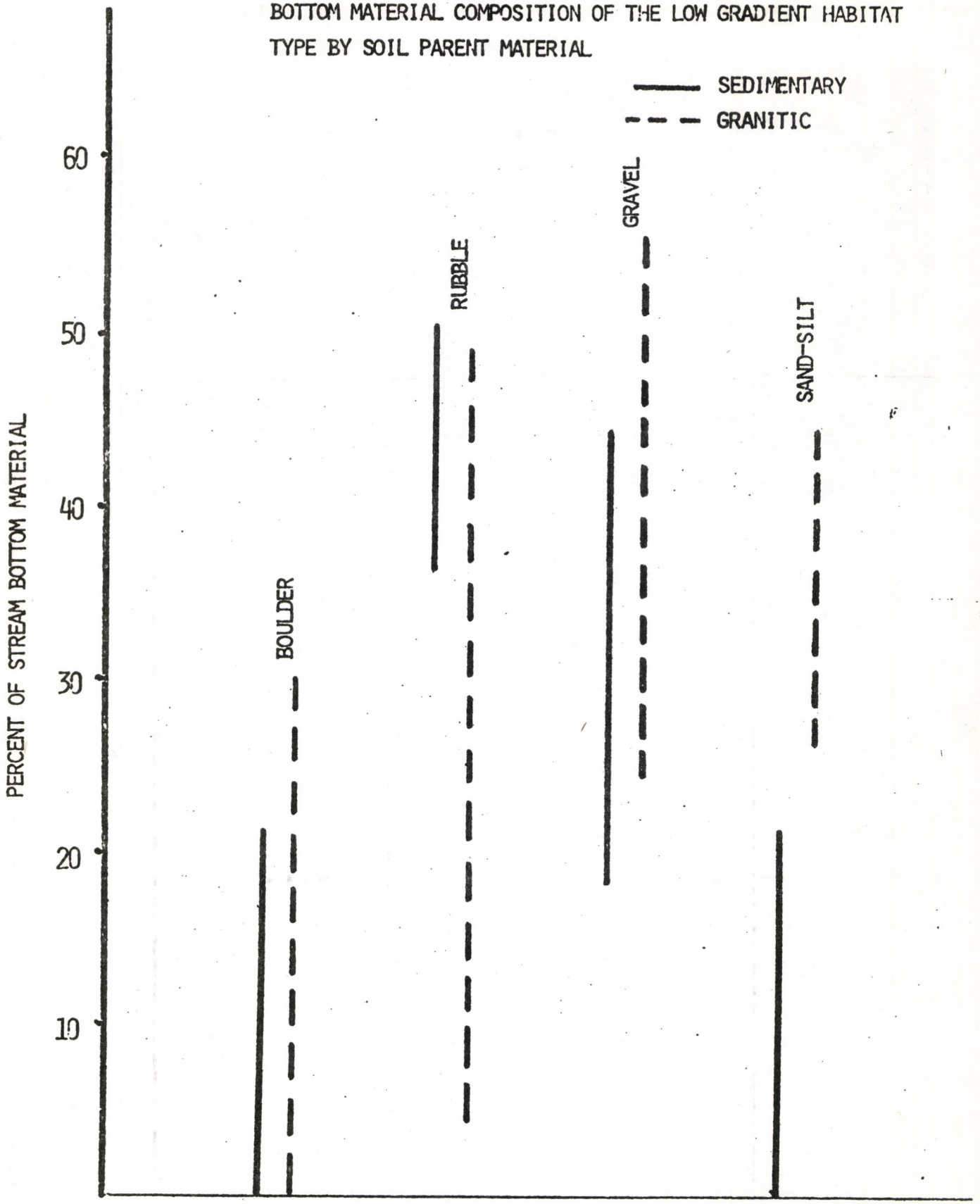


FIGURE 6

BOTTOM MATERIAL COMPOSITION OF THE LOW GRADIENT HABITAT TYPE BY SOIL PARENT MATERIAL



VALLEY BOTTOM (GRADIENT) HABITAT TYPES AND MANAGEMENT CAPABILITIES

South Fork of Gypsum Creek near Pinedale, Wyoming (left) and Cottonwood Creek near Afton, Wyoming (right).

Steep Gradient Stream Valley Bottoms - Aquatic Habitat Type No. 1

These valley bottoms are associated with stream segments having an overall gradient greater than three percent. Nearly all of these valley bottoms are located outside of Depositional Lands. These valley bottoms are narrow with steep slopes generally on either side; however this does not always hold true at higher elevations. Streams are almost always constricted by these slopes and are prevented from meandering on a valley floor such as occurs in Valley Bottom Habitat Types 2 and 3. The action of the streams in this habitat type is one of cutting and the transporting of materials to other aquatic

habitat types.

The soils in these valley bottoms are commonly shallow forming a thin mantle over bedrock. In some areas the streams are cutting into this bedrock. Cutting is also taking place in slump material and glacial debris depending upon the location of the stream. These soils support a variety of plant communities including sagebrush/forb/grass, shrub/forb and mixed conifer and aspen with shrubs. Most of the slopes either support a conifer type community or a sagebrush/aspen/forb/grass type, depending upon the aspect of the slope.

Stream bottom composition may vary from stream to stream but in general it is fairly constant. Expected composition is as follows:

Bottom Material Diameter		Percent Granitic	Percent Sedimentary
Boulder	(30.5 cm)	50 to 70	35 to 60
Rubble	(7.7 cm to 30.5 cm)	5 to 25	35 to 60
Gravel	(3.2 mm to 76 mm)	5 to 15	5 to 15
Sand-Silt	(3.2 mm)	0 to 10	0 to 10

Management Capabilities

1. There is little space in this valley bottom for any major forest activity.
2. Any forest activity needs to consider flood levels, potential sediment production, and water quality control.
3. Roads and administrative sites should be located outside of these valley bottoms.

4. Roads constructed in these valley bottoms will place major impacts upon the aquatic habitat.
5. Open bottom bridges should be used to cross all streams supporting a fishery to allow for fish migration.
6. Culverts used on non-fishery streams should be placed so as not to increase sediment production downstream.
7. Wider buffer zones are needed between timber management areas and valley bottoms in order to protect the aquatic habitat.
8. Streams in this habitat type will pass sediment due to gradient.
9. Beaver activity is limited in this habitat type.
10. Fisherman use will be lowest in this habitat type.

Gypsum Creek in the upper meadows north of Pinedale, Wyoming (left) and Larsen Creek on the Sweetwater River near the Bridger Wilderness boundary (right).

Intermediate Gradient Stream Valley Bottoms - Aquatic Habitat Type No. 2

These valley bottoms are associated with stream segments having an overall gradient between two and three percent. Nearly all of these valley bottoms are located in Depositional Lands. Although these valley bottoms are separate Habitat Types they are greatly influenced by the Landtype Associations surrounding them.

Gradients are such that materials carried by the streams are being both deposited and removed from the valley bottom. Most of the materials in these bottoms were deposited at an earlier time. The overall action of the streams in these bottoms is one of cutting, although in some areas this is difficult to recognize.

The soils in these valley bottoms are commonly deep, but not as deep as those found in Habitat Type 3. Stream channels are generally banked by old depositional gravels and sand and mud bars. Much of the stream banks are very wet and subject to periodic

flooding during spring runoff, but become dry as the summer progresses. Soil textures range from fine to coarse loamy with the finer textured soils (increased clay content) being derived from sedimentary rocks. The coarse textured soils (increased sand content) were noted to have been derived from granitic rock. These soils support willow/sedge/grass communities, and some sagebrush with scattered patches of aspen and conifer in some areas. The remaining 30 to 40 percent of the alluvial bottom consist of coarse loamy, rocky soils with up to 60 percent rock in the lower portion of the profile. These well-drained soils support a sagebrush/forb/grass community with scattered and small patches of conifer.

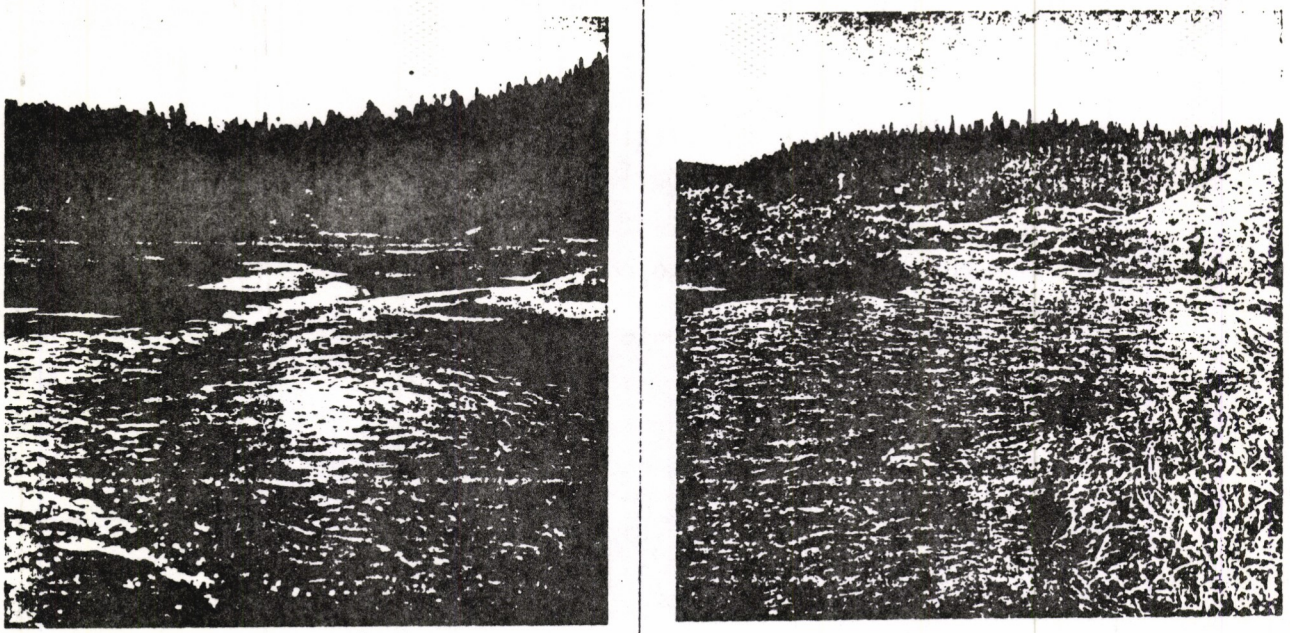
The number of pools in the bottom type is adequate to support a fair population of fish in most streams. In addition, approximately 50 percent of the stream bottom is adequate for spawning. Stream bottom composition may vary from stream to stream, but in general, it is fairly constant. Expected composition is as follows:

Bottom Material Diameter		Percent Granitic	Percent Sedimentary
Boulder	(30.5 cm)	10 to 35	10 to 40
Rubble	(7.7 cm to 30.5 cm)	30 to 50	30 to 60
Gravel	(3.2 mm to 76 mm)	10 to 40	10 to 35
Sand-Silt	(3.2 mm)	5 to 25	0 to 25

Management Capabilities

1. Wet sites and areas where periodic flooding may occur will limit forest management activities.

2. Any forest acitivity has to consider flood levels, potential sediment production, and water quality control.
3. Portions of this aquatic habitat type produce good forage for livestock and big game.
4. Livestock and big game tend to concentrate along stream banks due to the narrow width of these valley bottoms resulting in a general bank deterioration.
5. Road and administrative sites should be located outside of these valley bottoms. Benches and slopes above are generally better locations for these activities.
6. Open bottom bridges should be used to cross all streams supporting a fishery.
7. Road crossings should be located in areas where there is little stream meandering to minimize the impact upon the aquatic habitat and prevent damage to the road.
8. Buffer zones between timber management areas and valley bottoms need not be as wide as in the steep gradient habitat type.
9. Streams in this habitat type will pass and relocate sediment due to gradient. The overall action is one of passing sediment.
10. Beaver activity can be expected to be high in portions of this habitat type.
11. In portions of this aquatic habitat type fisherman use will be high.



East Fork River in Poston Meadows south of Boulder, Wyoming (left) and the Greys River above Forest Park (right)

Low Gradient Stream Valley Bottoms - Aquatic Habitat Type No. 3

These valley bottoms are associated with stream segments having an overall gradient less than two percent. All of these valley bottoms are located in Landtype Association 3, Depositional Lands (Oakes, 1974). Gradients are such that materials carried by the streams are being deposited in the valley bottom. This has resulted in the development of wide flood plains as the stream meanders across the valley floor.

The soils in these valley bottoms are commonly deep with soil depths to 25 feet plus, not uncommon. Stream channels are immediately banked by depositional gravels and sand and mud bars. Much of the streambanks, and probably as much as 60 to 70 percent of the alluvial

bottoms are very wet and subject to periodic flooding. Soil textures range from fine to coarse loamy with the finer textured soils (increased clay content) being derived from sedimentary rocks. The coarse textured soils (increased sand content) were noted to have been derived from granitic rock. The wetter soils support willow/sedge/grass communities. The remaining 30 to 40 percent of the alluvial bottom consists of coarse loamy, cobbly soils with up to 60 percent rock in the lower portion of the profile. These well-drained, drier soils support a sagebrush/forb/grass community with scattered small patches of conifer.

Bottom composition may vary from stream to stream, but in general, it is fairly constant. Expected composition is as follows:

Bottom Material Diameter		Percent Granitic	Percent Sedimentary
Boulder	(30.5 cm)	0 to 30	0 to 20
Rubble	(7.7 cm to 30.5 cm)	10 to 50	35 to 50
Gravel	(3.2 mm to 76 mm)	25 to 55	20 to 45
Sand-Silt	(3.2 mm)	25 to 45	0 to 20

Management Capabilities

1. Wet sites and areas where periodic flooding may occur will limit forest management activities.
2. Any forest activity has to consider flood levels, potential sediment production, and water quality control.
3. Most of this habitat type produces excellent forage for livestock and big game.

4. Consideration should be given to the protection of streambanks due to concentrated use by livestock or big game.
5. Road and administrative site locations should be kept on the benches and slopes above.
6. Crossing of this habitat type by roads should be avoided if possible. However, if roads are necessary they should be located in areas where there is little stream meandering.
7. Open bottom bridges should be used to cross all streams.
8. Buffer zones between timber management areas and valley bottoms need not be very wide.
9. Streams in this habitat type will relocate sediment due to gradient.
10. Beaver activity can be expected to be high in portions of the habitat type.
11. Fisherman use will generally be greatest in the aquatic habitat type.

Conclusions

This systematic approach to the stratification of the Valley Bottom Habitat Type offers the fishery biologist a unit of land that is easily related to. Most important, it offers the land manager an identifiable piece of land with capabilities to help in making sound management decisions.

The approach used in this report is based on only one year's data, however, the data does indicate that a segment of one stream does contain the same habitat type as a similar segment, in another stream. More data is needed to confirm this assumption. Nevertheless, there are strong implications that these Habitat Types have certain management capabilities and can be managed as separate units of land. The aquatic habitat needs to be described more completely in each of these habitat types. This report does not describe the aquatic habitat in any detail; however, if enough data were available this could be done. This approach offers the biologist enough data for present land use planning levels and a base that can be built upon as more data becomes available without changing to a new system each time.

AQUATIC HABITAT INVENTORY AND APPRAISAL, FIFTH WATER, SIXTH WATER, AND DIAMOND FORK BELOW THREE FORKS

Donald Dunham
Regional Fishery Biologist
U.S. Forest Service, Ogden, Utah
April 1963

Between November 21 and 27, 1962, Don Proctor, Uinta National Forest, and Don Dunham, Division of Wildlife Management, collected aquatic habitat survey data on Fifth Water, Sixth Water, and Diamond Fork below the Three Forks area. Don Proctor, at the time of field survey, was an employee on the Spanish Fork Ranger District.

Habitat survey data were collected primarily to evaluate the Central Utah Project (initial phase) water development effects upon National Forest aquatic resources. Staffman Walter H. Sundell and Ranger Reed C. Christensen, Uinta N.F., have requested that habitat survey data for above listed streams be documented and sent to them. These data should be of value to them in their multiple use management of National Forest resources.

Our field procedure emphasized evaluation of the resource as habitat. Sample areas were located at 1-mile intervals on stream course (see map tracing.) Each sample area was inventoried as to its aquatic habitat. We defined and evaluated habitat through three major groups: viz., water surface, streambottom, and streambank. (See sample form)

An important aspect of habitat inventory is that of identifying possible limiting factors. Welch, in "Limnology," states that for productivity potential there is good reason to believe that physical factors are more influential in streams than in lakes.

These streams are located within easy daily driving distance of the large Utah County population centers. Heavy angling pressures can and do develop. This factor alone dictates certain aspects of fish management programs. Major emphasis now, by the Utah Fish and Game, is the planting of catchable-size trout for the creel. By their inventory survey of these waters, conducted about 1955, Project No. F-2-R-3 report, they assigned "D" ratings to lower Diamond Fork and all of Sixth Water. "B" rating was assigned to Upper Diamond Fork and Fifth Water. By their definition:

> "D" streams are not suitable for cold water fish at any time.
>
> "B" streams include all streams except those qualifying as "A" streams and those streams not suitable for trout or without permanent conditions suitable for trout. Such streams have a fishing pressure apparently greater than the stream's ability to produce fishing. Such streams require stocking of catchable-size trout. These streams are characterized by a permanency of acceptable trout habitat although the various physical and ecological characters may vary considerably.

We here evaluate and report habitat using the Preliminary Aquatic Habitat Inventory and Analysis Procedure developed by personnel of the Division of Wildlife Management.

A total of 22 sample areas was inventoried. Pool ratio measure for all areas is reported below by class intervals. Pool measure of 100 equals a measured 50-50 pool-riffle ratio. A pool measure of 50 equals a measured 25-75 and/or 75-25 ratio. Other pool measure values equal pool-riffle ratios as related to the 100% equals a 50-50 ratio.

Pool measure	No. sample	Percent of samples
50 - 100	6	28
25 - 49	8	36
0 - 24	8	36

Seventy-two percent of the above 22 total samples have actual pool-riffle ratios below 25-75. Generally we may consider this physical condition as a habitat limiting factor.

The following table summarizes fish pool characteristics separately for cross-section lines and by bank stability classes as indicated. The total 22 sample areas is composed of 232 individual cross-section lines.

Table 1. Fish pool summary data grouped by bank stability classes. Stable = both bank points of the individual cross-section line fall at stable streambank points; mixed = one bank point stable the other unstable; unstable = both bank points unstable.

Class	Number x-section Lines	Surface Average Width	Total feet of Pools	Pool location (in feet) Center	Bank	Pool cover feature (by feet of pool) Vegetation	Boulder	Other
STABLE								
Fifth Water	2	10	5.0	5.0	-	-	5.0	-
Sixth Water	10	15	6.7	2.1	4.6	-	6.7	-
Diamond Fork	2	23	6.0	-	6.0	6.0	-	-
Total	14		17.7	7.1	10.6	6.0	11.7	-
Average per line			1.26					
Percent of total pool				40	60	34	66	
MIXED								
Fifth Water	19	7	1.63	1.47	.16	-	1.42	.21
Sixth Water	28	17	4.04	2.86	1.18	-	3.46	.57
Diamond Fork	6	24	3.33	.67	2.67	2.67	.67	-
Total	53		9.00	5.00	4.01	2.67	5.55	.78
Average per line			.17					
Percent of total pool				56	44	30	62	8
UNSTABLE								
Fifth Water	30	10	3.13	2.06	1.07	.13	2.83	.17
Sixth Water	64	18	3.62	3.30	.32	-	3.20	.41
Diamond Fork	71	23	1.76	.45	1.31	.37	.97	.42
Total	165		8.51	5.81	2.70	.50	7.00	1.00
Average per line			.03					
Percent of total pool				68	32	6	82	12

There is little doubt that average pool width per line is much reduced from stable streambank to the unstable condition class. Too, at unstable streambank cross-section lines, pools are located in the stream center area. Stream center pools have primarily boulder cover features. Vegetation (roots, overhanging banks, etc.) associated pools are exclusively those found along streambanks and located primarily at stable and to a lesser degree along mixed streambank class lines.

Streambottom is important in providing living areas for water stages of insect life which are important trout food items. Generally speaking for bottom types not having higher aquatic plants, rubble and gravel support more insect larvae readily available to trout. Silt bottom will frequently show greater insect production, but frequently these insects are of the type that because of their preferred living habits may be less readily available to trout as food.

An important consideration in sand or silt bottom is the potential obliteration of gravel spawning beds. In addition, viable trout eggs may be smothered by sediments. Sediments also may fill in pool areas.

The following summarizes streambottom types as their percent of occurrence and calculated total area for each stream.

	Total surface acres	STREAMBOTTOM[1/]				
		Boulder	Rubble	Gravel	Sand-Silt	Bedrock
FIFTH WATER	5	40 (2)	21 (1)	19 (1)	17 (1)	5 (.3)
SIXTH WATER	23	46 (11)	40 (9)	4 (.9)	Trace	8 (2)
DIAMOND FORK	23	5 (1)	44 (10)	48 (11)	3 (.7)	

1/ Open figure is percent of total bottom width measurement. Figure in parenthesis is the calculated acreage for the stream course.

Fifth Water presents special management problems. There are located, between stations 25 and 26, extensive hot spring areas. The water during the field survey was warm to the touch, indicative of high water temperature, perhaps even lethal for trout. In addition, water chemistry may show inimical properties for fish life. Numerous waterfall barriers for fish migration occur in the area between station 25 and station 27.

SUMMARY

Habitat inventory was completed in November 1962 on Fifth Water, Sixth Water, and Diamond Fork below Three Forks.

Inventory procedure is that now being used in Region 4 and developed by personnel in the Division of Wildlife Management. The procedure emphasizes evaluation of the watercourse as habitat for cold water fishes.

A total of 22 sample areas provided inventory information. Each area comprises 450 lineal feet of stream at 1-mile interval. Ideally, similar appraisal should be conducted for Diamond Fork and Halls Fork above the Three Forks area.

Summary of habitat data follows:

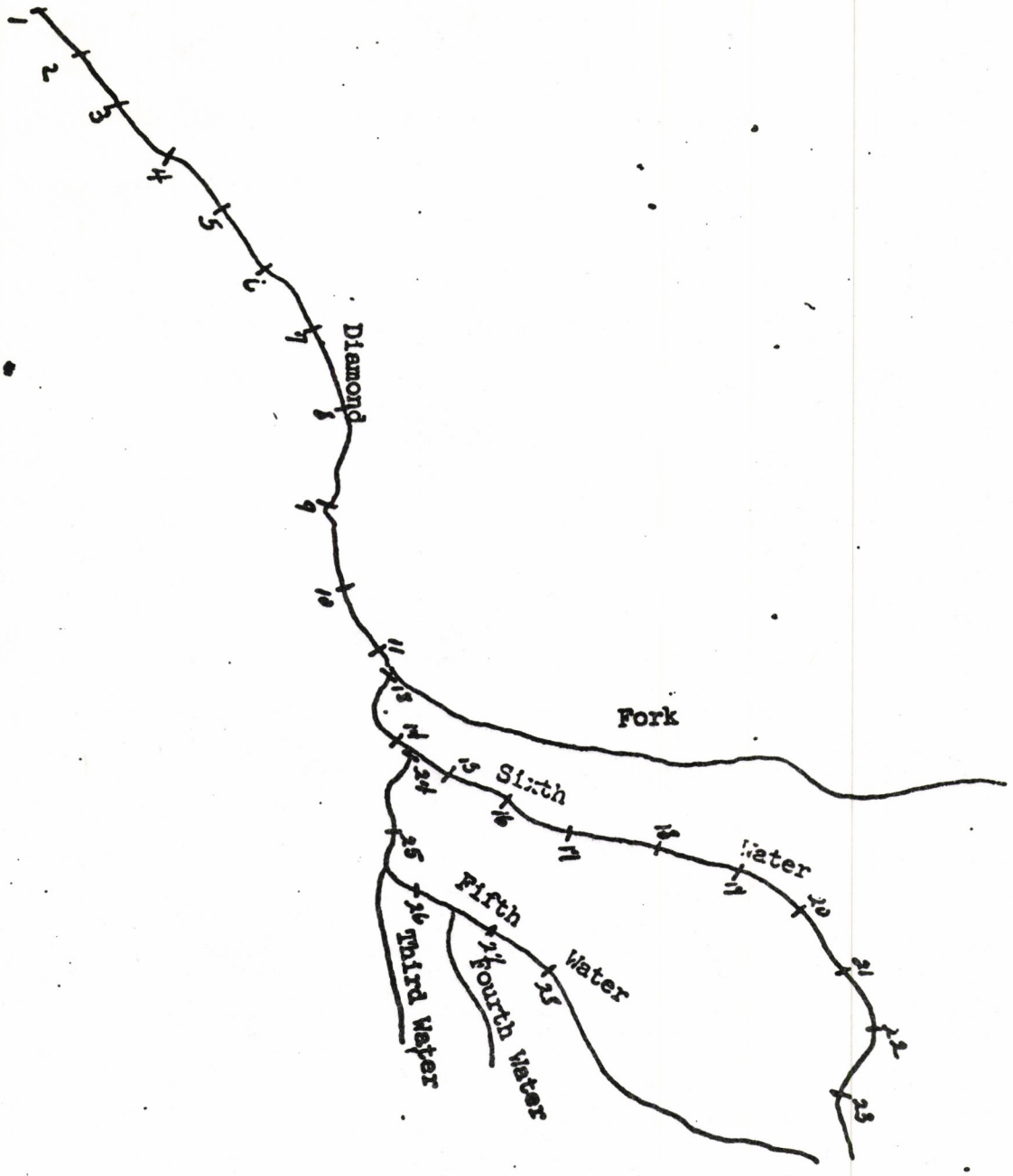
1. Pool measure.

   a. Cross-section lines at stable streambanks averaged 1.26 feet of pool per line. Mixed streambank class averaged .17 feet of pool per cross-section line and unstable banks averaged .03 feet of pool per line.

   b. Percentagewise stable streambanks averaged 60% of their pools associated with the streambank. Mixed and unstable classes had 44% and 32% respectively.

   c. Percentagewise, 34% of stable streambank pools had vegetation as the primary cover feature. For mixed and unstable this percentage was 30% and 6% respectively.

2. Streambottom was evaluated for the entire stream(s). Significant if what appears to be a deficiency of spawning gravel beds in Sixth Water and to a lesser degree, Fifth Water. Sixth Water has .9 acres of gravel throughout and Fifth Water has one acre of gravel.


Diamond
Fork
Sixth
Water
Fifth
Water
Fourth Water
Third Water

SAMPLE NUMBER HABITAT DATA SUMMARY TABLE

Sample Number	Pool Measure	Pool Structure 1/	HABITAT Stream Bottom	HABITAT Stream Environment	Total/ Max	As Percent of Optimum	Percent Bank Stability	Percent Aquatic Vegetation	Average Width
FIFTH WATER									
24	68	44	27	92	231/400	58	35		9
25	80	25	31	100	236/400	59	20		10.3
26	46	12	40	99	197/400	49	14		9
27	36	22	32	95	185/400	46	5		8
28	16	13	73	75	177/400	44	40		6.5
Stream average	49	23	41	92		51.2	23	Trace	8.6
SIXTH WATER									
13	58	34	90	78	260	66	25		18.9
14	52	42	33	95	222	55	45		15.7
15	18	00	42	99	159	40	50		16.3
16	-	-	-	-	-	-	-	-	-
17	92	43	27	85	247	62	20		18.8
18	48	10	42	75	175	44	30	16	17.8
19	40	21	64	63	188	47	15	56	20.4
20	30	17	60	60	167	42	46	34	19
21	22	4	51	55	132	33	00	31	17.9
22	46	21	8	70	145	36	00	61	14.3
23	58	48	19	75	200	50	00	76	16.8
Stream average	46	24	44	76		48	23	27	17.6
DIAMOND FORK									
1,2,3,4,5	00	00	99	44	143/400	36	00	17	25
6	8	8	97	50	147/400	37	10	16	25
7	36	23	83	46	193/400	48	20	7	29.9
8	22	22	97	63	204/400	51	15	6	23.7
9	20	18	88	93	219/400	55	00	3	22.6
10	28	17	82	76	203/400	51	5	7	21.3
11	14	00	94	74	182/400	45	00	2	19.5
Stream average	18	13	92	64		46	7	8	23.9

1/ Percent of total pools rated 1, 2, and 3

INTERSTATE HIGHWAY 70 LOCATION

AND SALINA CREEK AQUATIC HABITAT

Donald Dunham
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April 1966

Salina Creek heads in on the Fishlake National Forest in a mountainous area of the Wasatch plateau on the north and Fishlake plateau on the south at elevations reaching 11,000 to 16,000 feet. The stream courses drain north and south and westward a distance of about 30 miles to its confluence with the Sevier River near the town of Salina. The lower 5 miles (approximate) of channel are subject to discharge regulation by operation of a diversion near the Forest boundary.

Salina Creek is a trout stream receiving moderate fishing pressure and annually is planted with catchable-size hatchery reared trout. Fish population data assembled by Utah Fish and Game personnel show cutthroat, rainbow, and sucker above Meadow Creek, and rainbow, brown trout, coarse, and rough fish below Meadow Creek.

During October 1965, Fishlake N.F. personnel, under guidance and technical direction from the R-4 Regional fishery biologist, conducted an aquatic habitat inventory on Salina Creek, Sevier County, Utah, following procedures outlined in R-4 preliminary aquatic habitat inventory method.

Data collected are reported here and used to form an estimate of the effects upon the Salina Creek aquatic habitat which may result from construction of the Salina Canyon segment of Interstate Highway 70. Design of the Salina Canyon segment is approaching completion, and preliminary highway location plans were made available to the field parties by courtesy of the Richfield office, Utah State Department of Highways. This study is based upon the proposed centerline location shown in plans received on or about October 10, 1965, by the Fishlake Forest Supervisor. Recommendations are given to use in maintaining the existing fishery values of Salina Creek.

METHOD

Habitat rating. R-4 habitat analysis procedure reports habitat as a precent of optimum. Calculation is done using the four features of pool measure, pool structure, streambottom, and stream environment. Data is collected using an intercept method consisting of cross-channel lines evenly spaced at 50-foot intervals along the stream course. A single sample consists of five such cross-channel lines except the entire length of segments proposed for channel alteration is inventoried by 50-foot spaced intercept lines. No sample has less than five lines. Habitat aspect of water, streambottom, and streambank immediately underneath the intercept line is evaluated, quantitatively identified, and the appropriate entry recorded in the field form. Details of the procedure are in the R-4 Preliminary Procedure for Aquatic Habitat Inventory. Copies of the procedure are available at Forest Supervisor offices and in the Regional Office, Division of Wildlife Management.

Field. The problem is to determine what the Salina Creek habitat values are and how these values will be affected by construction of the proposed Salina Canyon segment of Interstate 70. Interstate 70 will parallel Salina Creek water course from Meadow Gulch to the Salina City interchange. As now planned, at least 36 channel changes will be needed if construction is done to locate the highway as shown in plans received October 10, 1965. To get at the habitat value for Salina Creek, line intercept sampling was done at uniformly spaced intervals along the entire length of Salina Creek from the Forest boundary near Salina City, upstream to Meadow Gulch. Distance is about 19.5 miles of stream. Nine five cross-channel line habitat inventory sampling stations were uniformly spaced at 2-mile intervals along Salina Creek with the first and lowermost sample point chosen by drawing lots. Data collected at these stations will be identified as Control.

With a habitat base established for Salina Creek, it becomes a matter of determining what are the habitat values in the segments proposed for channel alteration and is this habitat essentially the same as Control? Again, nine habitat inventory sampling stations were selected at uniformly spaced intervals along the lengths of proposed channel alterations, which, in this case, totalled 3.5 miles of stream. Each of 36 proposed channel alterations was inventoried and contiguous representative samples were drawn from the total. Visualize the 35 separates laid end to end with a cumulative total 3.5 miles, and along this 3.5 miles, nine samples were evenly spaced but with the requirement that samples be contiguous and not fall in more than one channel alteration segment. Data collected at these stations will be identified as Highway.

Statistical. Sample data collected in Control and Highway are statistically analyzed for standard errors, variance and tests of independence using chi square. Computational procedures are not included.

RESULTS

Mean habitat percent of optimum ratings for Control and Highway samples are 35.0 and 40.3, respectively. T-test of the standard error of the difference in means demonstrated no significant difference at the 99% probability level. Calculation of the t-test is shown below and since the calculated value of t, 1.11, is less than the 99% tabular value, 2.92, we would reject, on the basis of this test, the hypothesis that mean ratings identify two distinct habitat values. We have no reason to believe that Highway data represents higher value habitat than Control.

	No. samples	% mean rating	Difference in rating	Pooled std. dev.	Std. error of difference	Value of t calc.	Value of t 99% table
ontrol	9	35.0	5.3	10.18	4.77	1.11	2.92
ighway	9	40.3					

Further statistical analysis of data was made to substantiate methodology in using percentage figures for rating calculations. To do this, a chi square table was prepared for testing actual versus expected frequencies of the field data grouped by habitat items. For this step, unit values are ignored and emphasis placed upon ratios of individual entries to the total. Table 1 reports these data.

Table 1. Test of actual versus expected frequencies in habitat items.

	Pool measure	Pool structure	Stream-bottom	Stream environment	Totals	Habitat % of optimum
Control						
Actual	71	29	516	228	844	35.0
Expected	110.09	24.14	484.77	225.00		
Highway						
Actual	157	21	488	238	904	40.3
Expected	117.91	25.86	519.23	241.00		
Totals	228	50	1004	466	1748	
X^2	26.782	1.891	3.89	.077	32.64	

The probabilty of a larger value of chi square for three degrees of freedom is less than 1%. This low, a probability, suggests that Control and Highway sample data may not necessarily have been drawn from the same habitat and that differences are too large to be accidental.

The disagreement between the t-test of the standard error of difference in mean ratings and the chi square test of actual versus expected frequencies may be accounted for in part as a reflection of this, or for that matter, any rating system using precent figures. Changing data to percentages may mask differences that here have been demonstrated through chi square calculations. About the only meaning given to this situation is that use of the habitat percent of optimum rating figure is not to be considered fully adequate to measure differences between habitat. Percent of optimum, however, is a convenient reporting tool and is to be retained.

How then do these habitats differ. The very significant chi square to frequencies in Table 1 suggests that pool measure and streambottom may account for this difference or that differences may actually exist between Control and Highway in every habitat item and demonstrate statistical significance at 5% level upon the most simple grouping. Tests of independence between Control and Highway pooled data in each habitat category using chi square are summarized below.

Attribute	Control	Highway	Chi square	Probability
Pool measure	71	157	44.6	below 1%
Pool structure				
Ratio to total	29	21	1.89	18%
Ratio to pool measure	29	21	19.41	below 1%
Streambottom	516	488	.27	62%
Stream environment			1.86	40%
Tree	4	3		
Brush	64	65		
Exposed	14	23		

It would appear that Control and Highway differ primarily in the amount of pool (pool measure) and the magnitude of this difference is sufficiently great to differentiate the two to the extent that the study and sampling is competent.

As a further check, analysis of variance was completed for pool measure data. The resulting calculated variance ratio, F, of 32.08, is considerably greater than the tabular 99% F value, 8.53, further confirming that pool measure differences are significant.

Undoubtedly, some systematic errors, as well as limitations from sampling, are present in these data. The use of several crews with insufficient replications to identify within and between crew variations casts some question on the validity of data comparison. Confidence limits associated with the sample size chosen for this study are comparatively great and some question will be raised as to whether or not apparent differences are merely normal variations in sampling distribution.

DISCUSSION

Techniques for appraising aquatic habitat resources usually call for ocular estimates of the occurrence and abundance of various physical environmental features. It is a well known fact that ocular methods for estimating abundance, etc., will produce wide variation as several individuals report on the same size plot, area, or whatever is sampled. Line intercept sampling for aquatic habitat may be expected to reduce this variability and provide valuable data. The line intercept technique used here demonstrated significant habitat differences for samples drawn from Control and Highway.

Though habitat differences were demonstrated, we may ask the question, "How important are these differences in maintaining a satisfactory Salina Creek habitat?" We can better answer this question by reviewing Salina Creek in relation to other streams similarly rated and by recalling Salina Creek habitat data already presented in this report.

National Forest segments of streams similarly rated are ranked below:

Stream	State	Av. Width	% of Optimum
Fish Creek	Wyoming	16 ft.	64
Montpelier Creek	Idaho	13	62
Fifth Water	Utah	8	51
Trail Creek	Idaho	18	50
Diamond Fork	Utah	22	49
Sixth Water	Utah	15	48
Currant Creek	Utah	21	46
Wolf Creek	Utah	8	44
Moose Creek	Idaho	27	44
Rock Creek	Utah	40	41
SALINA CREEK (HIGHWAY)	Utah	19	40
West Fork Duchesne	Utah	22	40
Game Creek	Idaho	17	39
Taft Creek	Nevada	7	37
SALINA CREEK (CONTROL)	Utah	20	35
North Fork Duchesne	Utah	36	33
Hades Creek	Utah	10	25

Both Highway and Control rank Salina Creek below the median, 42.5, of the listed ratings. Control ranks in the 4th quarter and Highway ranks in the 3rd quarter. By this grouping, it appears that Salina Creek, by both measures, ranks relatively low in habitat value. Following construction, the Salina Creek habitat would be lowered in value by altering better than average segments of Salina Creek.

How substantial an effect the proposed 18,400 feet of channel alteration may have upon the stream can best be assessed after actual construction of the road and channel changes. Channel seasoning and equilibrium between velocity, bottom, and channel side materials may retain many of the favorable features of the existing habitat. A post-construction habitat survey will adequately measure habitat changes and provide the basis for comparison to pre-construction habitat and habitat resource

mitigation. To provide the administrator with a guide to implementing study findings, habitat sampling was completed and is reported in Table 2 for each of 36 proposed channel changes, since in actual road construction, it is the channel change that will be done and recommendations are needed to aid in planning resource maintenance.

Table 2. Habitat ratings for thirty-six proposed channel changes. Figures in column two are rounded to the nearest 5-foot length.

Beginning highway stations	Existing channel length	Pool measure	Pool structure	Stream-bottom	Stream environment	Percent of optimum
154	300	0	0	68	75	36
216	300	14	0	65	68	37
227	550	46	0	59	69	44
241	300	36	0	60	54	38
290	265	96	0	64	63	56
294	230	100	0	71	50	55
389	360	70	0	47	69	47
410	430	38	23	71	50	46
424	530	22	17	78	55	43
441	400	30	0	78	64	43
470	1220	40	13	82	78	53
489	380	32	0	71	53	39
495	740	42	20	73	73	52
505	640	44	19	85	76	56
516	950	28	9	81	75	48
531	505	12	0	63	56	33
538	210	0	0	66	63	32
550	355	0	0	36	50	22
559	520	16	16	60	55	37
598	970	0	0	77	49	32
609	550	12	0	80	52	36
620	365	60	22	61	72	54
625	1470	38	3	62	70	43
676	850	40	0	28	38	27
687	320	70	0	69	68	52
725	255	62	14	23	79	45
730	295	36	0	16	71	31
747	345	62	16	17	79	44
760	710	42	23	13	75	38
787	200	28	0	54	75	39
796	590	60	12	39	70	45
820	380	42	0	25	74	35
835	580	44	16	56	71	47
844	270	34	23	50	71	45
852	580	38	9	59	89	49
861	485	56	33	28	68	46
Total	18,400				Average	42.4